Scale, Skill, and Team Management: Organizational Structure of Mutual Fund Families

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Abstract

We develop a model of delegated portfolio management with two layers of agency problems, derive implications for single-manager vs. team funds, and test model implications using mutual fund data. A team fund with two managers can always operate as two separately-run funds and report the combined performance. Thus, a team fund should have at least as good a risk-adjusted performance as the two sub funds, with weighted average expected returns and lower risk due to diversification. Yet in reality we often observe lower performance for team funds. Our model explains why. Fund families optimally choose risk sharing contracts for their team funds to maximize their own profit. As a result, better skilled managers prefer not to join a team. Fund families design contracts to induce a mix of single-manager and team funds to maximize their own profit, which is different from maximizing fund performance for investors. Moreover, families with more convex compensation (e.g., due to convex fund flows) optimally choose a lower fraction of team-managed funds and have a lower average performance. We find empirical evidence consistent with our model's predictions regarding team management and fund performance.

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1 Introduction

In his AFA presidential address, Sharpe (1981) asks the question of whether and how investors could hire multiple investment managers, assuming they could identify superior managers. The short answer is, it is a hard question. Under *strong* assumptions there is some hope to efficiently combine portfolios formed by *two* managers. According to ICI 2013 factbook, there are over 13 trillion assets under management and 8,752 open-end mutual funds available to investors. It's no trivia task for any investor to identify a set of superior managers and *efficiently* combine the portfolios constructed by these managers. Can fund families help on this issue?

There are interesting developments in the industry. Figure 1 illustrates the explosive growth of team-managed funds in the last two decades, increasing from about 30% of total net assets in early nineties to about 70% recently. Through team funds, fund families can potentially help investors combine talents and coordinate trades of multiple managers. However, the performance of team funds are, at best, unimpressive. As shown in Panel (c), during the twenty year period, team funds underperform single-manager funds for about two thirds of the time.

Nonetheless, some fund families take the team logic further and roll out the fund of mutual funds, which offers investors a diversified portfolio of managers in a single fund.[1] Through funds of funds, fund families take over the tasks of identifying (skilled) managers and (potentially) coordinating portfolios among the team of managers. At the opposite end of the spectrum, we observe fund families (especially hedge funds) offering multiple funds managed by the same fund manager, further increasing the choice set for investors. It is therefore important to ask whether fund families' incentives are aligned with investors' when they offer team funds, whether families would select star managers for team funds, how they can compensate team managers, and ultimately, whether the team format is beneficial for investors. In this paper, we explicitly model fund families' choices between single-manager and team funds and derive implications for team fund performance.

[1]See for example, an "all-in-one" fund, like Vanguard target retirement fund, which is "designed to help you simplify the way you manage your portfolio and reduce your investment risk" (*https://investor.vanguard.com/mutual-funds/all-in-one-funds*). Fund of funds is actually one of the fastest growing market segments in the mutual fund industry, with 1,156 funds of funds and 1.3 trillion TNA in 2012, according to ICI factbook.

A team fund with two managers can always operate as an independent team fund, which is a "fund of funds" without the additional layer of management fees. In particular, each manager has full discretion over his "sub-fund", maintains separate internal track records, and is compensated based only on his own performance. In this independent format, a team fund is merely a platform for the fund family to provide the combined performance to its investors. This team fund should have at least as good a risk-adjusted performance as the two sub-funds, with weighted average expected returns and lower risk due to diversification of investment risks and manager skills. Since it is always feasible for fund families to set up independent team funds, other team arrangements observed in practice should presumably be beneficial. Therefore, it is surprising that team funds often underperform. Our paper explains why.

We develop a model of delegated portfolio management with two layers of agency problems between investors, fund families and managers. Investors delegate their assets to fund families, who then hire managers to make investment decisions. Neither fund families nor investors can observe managers' ability levels, but managers know their own ability. Fund families design team and single-manager contracts to maximize family profit. Managers self-select into team or single-manager funds to maximize their own utility. We consider only the independent team structure and ignore any interactions within the team including information sharing, cost sharing, or hierarchical costs. Our model therefore provides an implementable benchmark for fund families and a good starting point to understand the benefits and costs of team contracts for fund families and investors.

For simplicity, we do not model the optimization problem of investors. Instead, we assume an exogenous contract between investors and fund families. Investors invest in all funds offered by the family and compensate each fund based only on its performance. The compensation can be either linear or convex in performance. The convex compensation is meant to capture either implicit contracts like convex flow-performance relation (Chevalier and Ellison (1997), Sirri and Tufano (1998) and Huang, Wei, and Yan (2007)) or explicit contracts like the limited liability of funds, asymmetric mutual fund advisory contracts (Starks (1987) and Grinblatt and Titman (1989)) or option-like incentive fee contracts for hedge funds (Ross (2004) and Agarwal, Daniel, and Naik (2009)).

Our first main result is on the design of team compensation contracts for fund families. Fund families can either provide risk sharing among team managers by basing compensation on the team performance and rewarding managers for their teammates' superior performance, or encourage fierce competition by overcompensating winning managers at the expense of losing managers. We find that fund families always prefer risk sharing contracts. The reason is that risk averse managers enjoy the risk sharing benefit. As a result, they are willing to take lower average compensation when offered risk sharing contracts. Fund families are risk neutral and maximize total profit which is the difference between management fees paid by investors and compensations to managers. Fund families find it optimal to always provide risk sharing team contracts, even though these contracts can lead to poor performance for team funds in equilibrium.

Our second result is that better skilled managers prefer single-manager funds to team funds. Given risk sharing team contracts offered by fund families, managers tradeoff the gain of diversification and pooling with better skilled managers with the loss of pooling with worse managers. For better managers, they are more likely to pool with worse managers and hence benefit less from team contracts. We find a unique separating equilibrium in which managers with skills above the cutoff level prefer single-manager funds and managers with skills below prefer to team. This self-selection by fund managers explains the poorer performance of team funds. This result is not new. Massa, Reuter, and Zitzewitz (2010) and Han, Noe, and Rebello (2012) have both established the self-selection of better managers into single-manager funds. Our main contribution is the first result which establishes that fund families optimally choose to offer risk sharing contracts for their teams, anticipating the self-selection of managers.

Our third result is that convex compensation for fund families leads to a preference for single-manager funds over team funds. When investors compensate fund families according to a convex schedule, fund families benefit more from two single-manager funds than from a team fund with the same two managers. The reason is that the team fund is likely to have mediocre realized performance after averaging two managers' performances, and families benefit less from the convexity of the compensation contract. This result points out a fundamental problem with team funds if investors do not recognize the benefit of lower risks and pay attention only to realized performances (Gruber (1996), Goetzmann and Peles (1997), Zheng (1999), and Huang, Wei, and Yan (2010)). With lower expected profit, a team fund can no longer replicate two independent single-manager funds regardless of whether families offer risk sharing contracts or not. It's also harder to retain good managers as a result.

Our fourth result is that fund families always design contracts to induce an interior mix of single-manager and team funds, and families with more convex compensation choose a lower fraction of team-managed funds. In the model, we simplify the analysis by endowing managers with information to avoid effort choices and eliminate the selection of manager pools by setting the reservation utility at a level that all managers participate in equilibrium. Therefore, the optimal organizational structure for investors who care only about fund performance is all team funds, because the risk-adjusted performance of a team fund is always better than the average of two single-manager funds due to diversification.

Yet fund families' incentive to maximize expected profit yields very different outcome from maximizing fund performance for investors. In particular, we find that fund families always prefer an interior mix of single-manager and team funds. This result holds even when the compensation from investors is linear in performance, because an interior mix allows fund families to extract more rents from higher ability managers, who are willing to accept low fixed compensations to avoid pooling with worse managers. When the compensation is convex in performance, fund families enjoy an added benefit of higher expected revenue from two single-manager funds. As a result, families with more convex compensation optimally choose a lower fraction of team-managed funds.

Our model yields several testable predictions for empirical study. First, fund families with more convex compensations have lower fractions of team funds. Second, within each family, team fund managers have worse skills than managers in single-manager funds. Third, across families, controlling for family performance, team fund (or stand-alone) managers in more convex-compensation families have worse skills than team fund (or stand-alone) managers in less convex-compensation families.[2]

[2]The last prediction follows directly from the first one. It is easier to illustrate the point with an example. Say top 20% of managers in the less convex family choose to be stand-alone managers while the fraction is 40% in the more

Empirically, we use CRSP Survivorship Bias Free Mutual Fund Database from 1992-2012 to test our predictions. We focus our analysis on 3288 unique actively managed U.S. domestic equity funds. We consider convex compensation due to the convexity of flow-performance relation. The main proxy we rely on is family size, since small fund families have more convex fund flow reaction to past performance (Huang, Wei, and Yan (2007)). We also conduct subperiod analysis since Kim (2014) find that the flow-performance relation is more convex in earlier years than in recent years. Next, we identify measures of skills based both on outcome (i.e., fund performance) and actions (i.e., portfolio management activeness). Outcome variables include four-factor alpha (Jensen (1968) and Carhart (1997)), the volatility of alpha, and information ratios. Action variables include industry concentration (Kacperczyk, Sialm, and Zheng 2005), return gap (Kacperczyk, Sialm, and Zheng 2008), and active shares (Cremers and Petajisto 2009).

Our empirical findings are largely consistent with our theoretical predictions. First, we find strong evidence that small fund families (i.e., the ones with more convex flow compensation) have lower fractions of team funds. In the time series, the explosive growth in team funds in recent years coincides with a decrease in the convexity of the flow-performance relation. Second, within each family, team funds have worse performance than single-manager funds, measured both by four-factor alpha or information ratio. Team funds are less active in managing their portfolios as measured by lower return gap, lower industry concentration, and a smaller fraction of active shares. Third, across families, after controlling for family performance, team (or single-manager) funds in smaller families have worse skills than team (or single-manager) funds in larger families, measured by both outcome and action variables.

Our paper is related to several strands of literatures. First, there is a theory literature on the benefits and costs of team-managed funds. Sharpe (1981) argues that team management can be beneficial for mutual fund investors due to specialization by fund managers and diversification across manager styles. Barry and Starks (1984) show that team management offers additional benefits by

convex family. Once we control for family performance, managers in the top 20% (stand-alone managers for the less convex family) are necessarily better than those in the top 40% (stand-alone managers for the more convex family). Similarly, managers in the bottom 80% (team managers for the less convex family) are necessarily better than those in the bottom 60% (team managers for the more convex family).

reducing agency problems between investors and managers. On the other hand, moral hazard in teams (Holmstrom (1982)) and hierarchical costs in organizations (Stein (2002)) can lead to poor performance of teams. The literature focuses on the interaction between team members in sharing and utilizing information and whether the team structure adds or subtracts value from their individual managers, which are clearly very important questions. We study the simplest possible team structure in which team members operate independently. Thus the team performance is by definition the sum of its members' performance, and is necessarily better due the diversification benefit. Our simple setting allows us to study the additional layer of agency conflict between fund families and investors and to understand its impact on the design of team contracts. We find that fund families optimally choose risk sharing team contract even though it may lead to poor team performance, and they design contracts to induce a mix of team and single-manager funds to maximizes their own compensation rather than fund performance.

Second, we contribute to the empirical literature on the performance of team-managed funds. Bliss, Potter, and Schwarz (2008), Bar, Kempf, and Ruenzi (2011), and Massa, Reuter, and Zitzewitz (2010) find inferior performance by team-managed fund despite their increasing popularity. Patel and Sarkissian (2014) attribute the inferior team performance to data error in which both CRSP and Morningstar datasets have large discrepancies in reported managerial structures relative to SEC records. Adams, Nishikawa, and Rao (2015) find that a subset of team-managed funds, namely, those with highly independent boards, perform better. Han, Noe, and Rebello (2012) use the self-selection of better managers to single-manager funds to explain the poor performance of team funds. They show that once managers' ability is properly controlled for, team funds perform better. We add to the literature by establishing the relation between the convexity of family's compensation and the fraction of team funds. Our results on cross-family comparisons of team and single-manager fund performances are also new.

Third, our paper is related to the literature on the decreasing return to scale for mutual funds. Pastor and Stambaugh (2012) argue that there is decreasing return to scale at the industry level because it is harder for managers to outperform passive benchmarks when the industry's size increases.

Berk and Green (2004) show that the decreasing return to scale at the fund level is a natural outcome when funds flow to superior managers but managers face decreasing returns in deploying their superior ability. Chen, Hong, Huang, and Kubik (2004) document empirically the decreasing return to scale at the fund level and attribute it to hierarchical costs (Stein (2002)), assuming larger funds necessarily employ multiple managers. Our story is complementary to the literature. We show that fund families can offer independent team contracts, which is easily implementable and does not suffer from hierarchical costs. Therefore, decreasing return to scale at the *manager* level does not necessarily translate to decreasing return to scale at the *fund* level. However, we also find that agency problems at the family level and self-selection of fund managers can lead to lower performance of team funds and decreasing return to scale at the fund level. It is worth pointing out that transaction cost is not a viable explanation for decreasing return to scale at the fund level whenever team management is an option. An independent team fund with two managers should always have lower transaction costs than two separately run single-manager funds, because it's always feasible to disregard any interactions between the two managers and form two independent portfolios.[3] Empirically, Busse, Chordia, Jiang, and Tang (2015) find that larger funds have lower percentage transaction costs than smaller funds.

The remainder of this paper is structured as follows: Section 2 sets up the model. Section 3 derives empirical predictions of the model. Section 4 explains the data sources and empirical results. Section 5 concludes.

2 Model

2.1 Model Setup

We consider an economy with a representative fund family and a continuum of fund managers $i \in \Omega$ with reservation utility $\underline{U} > 0$. Each manager has a unique trading strategy that generates excess

[3] Whenever the two managers have opposite trades, the team fund can cross trades and save transaction costs both ways. If two managers have similar trades, they have the option to reduce trade sizes if the combined price impact would have been too large. They could supplement these trades using other second-best trading ideas with lower trading costs. This combined outcome for the team fund is necessarily better than the outcome when two managers cannot coordinate trades in the case of the two separately run funds.

return $\tilde{\alpha}_i$. Without the manager's information, unconditional distribution of $\tilde{\alpha}_i$ is

$$\tilde{\alpha}_i = \begin{cases} \alpha, & \text{with probability } 0.5 \\ -\alpha, & \text{with probability } 0.5 \end{cases} \tag{1}$$

Prior to her trading, manager i receives a binary private signal $\tilde{s}_i$ about the outcome of the trading strategy. Conditional on a positive (negative) signal, probability distribution of excess returns is

$$\Pr\{\tilde{\alpha}_i = \alpha | \tilde{s}_i = +1\} = \Pr\{\tilde{\alpha}_i = -\alpha | \tilde{s}_i = -1\} = 0.5 + \sqrt{\tau_i}, \tag{2}$$

where $\tau_i \in (0, 0.25)$ is manager i's signal precision. Managers are risk averse with coefficient γ, and derive mean-variance utility over their compensation $\tilde{f}$. After receiving her private signal, manager i chooses trading amount x_i to maximize her utility:

$$U_i = E(\tilde{f}_i | \tilde{s}_i) - \frac{\gamma}{2} Var(\tilde{f}_i | \tilde{s}_i). \tag{3}$$

Assumption 1 *Managers are constrained in trading amount. In particular, manager i chooses whether fully or not to implement her trading strategy given her signal:*

$$x_i = \begin{cases} 1, & \text{if } \tilde{s}_i = +1 \\ 0, & \text{if } \tilde{s}_i = -1 \end{cases}. \tag{4}$$

A manager trades when her signal indicates that it is a good time to implement her trading strategy. At manager level, excess return is defined as

$$\tilde{R}_i = x_i \tilde{\alpha}_i. \tag{5}$$

Managers are heterogenous in skill level, which determines their individual signal precision. For manager i, precision τ_i is uniformly distributed over $\Phi = [\tau_L, \tau_H]$, which is a subinterval of $(0, 0.25)$. $\Omega \mapsto \Phi$ is a pointwise mapping from the pool of managers to their skill levels. Each manager's own skill is privately known by herself, but is unobservable for any other managers or the fund family in the economy. For expositional convenience, we have:

Assumption 2 *Private signals $\tilde{s}_{i_1}$, $\tilde{s}_{i_2}$, and excess returns $\tilde{\alpha}_{i_1}$, $\tilde{\alpha}_{i_2}$ are independent for $\forall i_1, i_2$ such that $i_1 \neq i_2$.*

There are two types of management structure in the family: single-manager and team-managed funds. A single-manager fund is solely managed by one manager, with W_0 assets under management(AUM) in the beginning. For simplicity, we assume that each management team consists of two managers, each also assigned with W_0 initial AUM. When a team-managed fund is set up, two managers self-selected from Ω will be randomly paired to manage it. For a single-manager fund managed by manager i, fund level excess return (with subscript j) is $\tilde{R}_j^S = \tilde{R}_i$. For a team-managed fund jointly managed by manager i and manager $-i$, fund level excess return is

$$\tilde{R}_j^T = \frac{1}{2}(\tilde{R}_i + \tilde{R}_{-i}). \tag{6}$$

Risk-adjusted performance is measured with *Information Ratio*. At manager level (with subscript i),

$$IR_i = E(\tilde{R}_i)Var(\tilde{R}_i)^{-\frac{1}{2}}. \tag{7}$$

At fund level, for a team-managed fund, *Information Ratio* is calculated as

$$IR_j^T = E(\tilde{R}_j^T)Var(\tilde{R}_j^T)^{-\frac{1}{2}}. \tag{8}$$

Alternatively, if it is a single-manager fund, fund level *Information Ratio* is equal to the manager level measure:

$$IR_j^S = IR_i. \tag{9}$$

The fund family hires managers from the manager pool. Its current period revenue comes exclusively from fixed management fees based on the total value of assets under management. Nonetheless, there is an implicit return-based incentive for the family: investors' future cash flows. When a fund delivers good excess returns, money flows into that fund. Moreover, the return-flow relationship is non-linear. A fund with outstanding realized excess returns will embrace much more inflows than a fund who marginally outperformed its peers. We capture the implicit contract in family revenue with the following assumption.

Assumption 3 *The fund family's revenue from fund j is a quadratic function of excess returns.*

Specifically, given fund excess return $\tilde{R}_j$*, revenue from fund* j *is*

$$\tilde{F}_j = AW_j + BW_j\tilde{R}_j + CW_j\tilde{R}_j^2, \tag{10}$$

where the initial AUM is given by

$$W_j = \begin{cases} W_0, \textit{ if fund } j \textit{ is single-managed} \\ 2W_0, \textit{ if fund } j \textit{ is team-managed} \end{cases} \tag{11}$$

Parameter $A > 0$ is the fixed part of management fees from the initial total AUM. B is the linear slope of the family's (present value of) future fees to fund return. The third term is the present value of future fees from the convex part of future inflows. Parameter C is the flow-convexity coefficient.

After paying managers their compensation, the fund family keeps the rest of its revenue as profit. Compensation contracts specify how a manager will be compensated in the end of the management period. The fund family offers different contracts for single-manager and team-managed funds: $\{S, T\}$.

There are three dates: $t = 0, 1$ and 2. At $t = 0$, the fund family offers compensation contracts to managers, who choose one of the two contracts to maximize her ex ante expected utility $E(U_i)$. At $t = 1$, managers receive private signals, and then trade to maximize their expected utility. All uncertainty is resolved at $t = 2$, and managers get compensated according to contracts.

In either contract, manager compensation is paid as the sum of two components: fixed salary, and an linear incentive based on terminal value of trading profit. A single-management compensation contract for manager i is

$$\tilde{f}_{i,S} = a_S + bW_0\tilde{R}_i, \tag{12}$$

where a_S is the fixed component of compensation, and exogenous constant $b > 0$ is an incentive slope that determines the proportion of trading profit $W_0\tilde{R}_i$ to be paid to manager i.

Team compensation contract is an extension of the simple single-management contract. For manager i, who works with manager $-i$ in a team, compensation is:

$$\tilde{f}_{i,T} = a_T + bW_0\tilde{R}_i + \phi W_0(\tilde{R}_i - \tilde{R}_{-i}), \tag{13}$$

where a_T is the fixed component of compensation. Parameter ϕ captures the flexibility of incentive policy for team managers. When $0 < \phi \leqslant \frac{b}{2}$, bonus will be additionally based on manager i's portfolio excess return relative to manager $-i$'s; when $-\frac{b}{2} \leqslant \phi < 0$, managers can share risk, as their compensation increases in excess returns of their teammates; when $\phi = 0$, managers' compensation differs from single-management contract only in fixed salary.

All parameter values and unconditional distributions are common knowledge in the economy. Note that given excess returns, total incentives paid to two single managers is always the same as that paid to a team of two managers. Thus, contract parameter ϕ serves as a costless policy tool for the fund family to maximize its objective, which is stated in the following assumption.

Assumption 4 *The fund family is risk neutral. It hires any manager randomly drawn from the pool Ω, and maximizes its $t = 0$ present value of expected profit from a new manager:*

$$\underset{\{a_S, a_T, \phi\}}{Max} \quad \Pi = E_0 \left[\tilde{\pi}_i (a_S, a_T, \phi) \right],$$

subject to managers' participation constraint:

$$\text{for } \forall i \in \Omega, \ \max \ \Big\{ E(U_{i,S}), E(U_{i,T}) \ \Big\} \geqslant \underline{U} \text{ regardless of the contract choice of } \forall i' \neq i$$

The participation condition implies that the fund family cannot select good managers by offering an unattractive compensation contract to drive mediocre managers out of the pool. Competition for scarce managerial skill dictates that the fund family must ensure any manager would at least accept one of the two contracts, or the family would lose its chance to draw new managers from the talent pool.

2.2 Manager Contract Choices

In this section, we examine managers' contract choices at $t = 0$ given contract paramers $\{\phi, a_S, a_T\}$. Manager i makes a decision based on common knowledge and her only private information at $t = 0$: her own signal precision τ_i. Given her belief on what other managers would choose with their skill levels and beliefs, she makes her choice. When every manager's prior belief coincides with everyone's posterior choice, and nobody has incentive to deviate from her choice, a Beyasian Nash Equilibrium is established.

We first calculate managers' ex ante expected utility from choosing either contract. Then, based on their rational choices from the two contracts, we analyze properties of such an equilibrium that are related to fund family's decision on other contract parameters.

2.2.1 Manager Welfare

For a manager with signal precision τ_i, if she chooses the single-management contract, her expected utility is calculated by averaging conditional expectation and conditional variance of compensation over realizations of her signal.

Given signal precision τ_i and conditional on $\tilde{s}_i = +1$ (good time to implement the trading strategy), excess return

$$E(\tilde{R}_i|\tilde{s}_i = +1) = 2\sqrt{\tau_i}\alpha, \tag{14}$$

and

$$Var(\tilde{R}_i|\tilde{s}_i = +1) = (1 - 4\tau_i)\alpha^2. \tag{15}$$

When $\tilde{s}_i = -1$ (bad time to implement the trading strategy), they are both zero. Insert compensation $\tilde{f}_{i,S}$ in equation 12 into utility function 3, and average over two possible states of the signal $\tilde{s}_i$,

$$E(U_{i,S}) = a_S + bW_0\alpha\sqrt{\tau_i} - \frac{1}{4}\gamma b^2 W_0^2 \alpha^2 (1 - 4\tau_i). \tag{16}$$

Expected utility increases in fixed salary a_S, and her own skill level, as skill brings higher expected profit with smaller risk. On the other hand, if the manager chooses team-management contract and works in a team with manager $-i$, conditional on the teammate's signal precision $\tilde{\tau}_{-i}$, her expected utility can be calculated in a similar way.

$$E(U_{i,T}|\tilde{\tau}_{-i}) = a_T + (b+\phi)W_0\alpha\sqrt{\tau_i} - \phi W_0\alpha\sqrt{\tilde{\tau}_{-i}} - \frac{1}{4}\gamma W_0^2\alpha^2[(b+\phi)^2(1-4\tau_i) + \phi^2(1-4\tilde{\tau}_{-i})]. \tag{17}$$

Her expected utility depends on not only her own, but also her teammate's skill level. The more skilled she is, the higher expected utility she obtains given the fixed salary a_T. However, relationship between $E(U_{i,T}|\tilde{\tau}_{-i})$ and $\tilde{\tau}_{-i}$ relies on parameter ϕ. When ϕ is positive, the more skilled your teammate is, the smaller your expectation of compensation will be. But higher $\tilde{\tau}_{-i}$ also reduces your uncertainty about terminal compensation. In contrast, when ϕ is negative and managers share risk with each other's strategy performance, ex ante expected utility increases monotonically in the teammate's skill.

When managers are making their contract choices, they have no information on the teammate's signal precision $\tilde{\tau}_{-i}$. Instead, they make the choice by comparing ex ante expectation of compensation from team-management with single-management contract. Define the sub-pool of managers that prefer to team as Γ, where $\Gamma \subset \Omega$. Then

$$E(U_{i,T}) = E[E(U_{i,T}|\tilde{\tau}_{-i})|\tilde{\tau}_{-i} \in \Gamma]. \tag{18}$$

Managers always choose the contract that makes them better off in terms of expected utility. For convenience, we define a useful function here: ex ante utility gap for manager with signal precision

$$G(\tau_i; a_S, a_T, \phi, \Gamma) = E(U_{i,T}) - E(U_{i,S}). \tag{19}$$

When $G(\tau_i; a_S, a_T, \phi, \Gamma)$ is positive for manager i, she chooses the team-management contract, and vice versa.

2.2.2 Equilibrium

When there are a large number of managers with heterogenous skill levels, each manager has a prior probability distribution regarding her potential teammate's skill if she chooses the team-management contract. The choice is made by comparing ex ante expected utility from single-and team-management contracts, with a prior belief on the sub-pool of managers that join teams. In equilibrium, since each manager's prior belief is consistent with every manager's ex post choice, the prior belief must be shared by all managers. Besides, managers' choices and beliefs are affected by a set of specific contract parameters $\{\phi, a_S, a_T\}$. We define the equilibrium first.

Definition 1 (Equilibrium) *A pure-strategy Perfect-Bayesian Nash Equilibrium in managers' contract choice game at* $t = 0$ *involves*

1) A common prior belief: any manager belongs to a subset of $\Gamma \subset \Omega$ *chooses the team-management contract, and other managers choose the single-management contract;*

2) Given a set of contract parameters $\{\phi, a_S, a_T\}$ *and other managers' choices in her belief, man-*

ager i's contract choice is

$$\underset{\{S,T\}}{Argmax}\Big\{E(U_{i,S}), E(U_{i,T})\Big\}. \tag{20}$$

3) Ex post, any manager belongs to Γ chooses the team contract, and the rest of managers choose the single-management contract.

Since the set of manager pool Ω is continuous, one might conjecture any continuous or non-continuous subsets Γ of managers would choose the team-management contract. The following lemma helps us focus on one special form of belief on Γ that is viable in equilibrium.

Lemma 1 (Cutoff skill level) *Given an arbitrary non-zero $\phi \in [-\frac{b}{2}, \frac{b}{2}]$, for any equilibrium defined above in the manager pool, there exists a threshold skill level $\tau_* \in [\tau_L, \tau_H]$. If $\phi > 0$ ($\phi < 0$), managers with skill levels below τ_* choose team-management (single-management) contract, and the rest of managers choose the other contract.*

Proof. See the Appendix. ■

For any continuous distribution of manager skill with a finite support of $[\tau_L, \tau_H]$, we have only this form of separating equilibrium. If managers with both better and worse skill than a certain manager choose the same contract, she also chooses that contract. Suppose one of the two contracts are attractive enough, all managers will choose that contract and we will see 100% of single-manager or team-managed funds. With the monotonicity in utility gap $G(\tau_i; a_S, a_T, \phi, \Gamma)$ as a function of τ_i, threshold manager's signal precision is

$$\tau_* = Max\left[\tau_L, Min(\hat{\tau}, \tau_H)\right], \tag{21}$$

where $\hat{\tau}$ is define as

$$\hat{\tau} = \{\tau_i : G(\tau_i; a_S, a_T, \phi, \Gamma) = 0\}. \tag{22}$$

In such an equilibrium, contract choices imperfectly signal managers' managerial skills. When a risk sharing rule is offered to team managers ($\phi < 0$), only relatively less skilled managers prefer the team contract, and more skilled managers all prefer the single-management contract. Given an equilibrium sub-pool Γ, the more skilled a manager is, the less likely that she prefers the team-management contract. If a relative performance rule is offered, in contrast, the relationship reverses and only more skilled managers prefer to team. So the sub-pool of managers who prefer to join teams must take the form $[\tau_L, \tau_*]$ or $[\tau_*, \tau_H]$. When ϕ is zero, everyone is indifferent between the single- and team-management contracts as long as the same fixed salary is offered. However, it does not make sense that the fund family creates team-management without any substantial difference for itself from traditional single-management structure.

Now we consider a case where a risk sharing rule within teams is created by the fund family ($\phi < 0$). We will show why this will happen in the next section.

Proposition 1 (Uniqueness) *Suppose $\phi < 0$, given contract parameters $\{a_S, a_T, \phi\}$, there exists a unique separating equilibrium. In particular,*

1) *When $a_T + c_1 < a_S < a_T + c_2$, $\tau_* \in (\tau_L, \tau_H)$;*

2) *When $a_S < a_T + c_1$, $\tau_* = \tau_H$;*

3) *When $a_S > a_T + c_2$, $\tau_* = \tau_L$.*

Where constants $c_1 = \frac{1}{6}\phi W_0 \alpha \left\{ \frac{2(\tau_H + \sqrt{\tau_H \tau_L} - 2\tau_L)}{\sqrt{\tau_H} + \sqrt{\tau_L}} - 3\gamma W_0 \alpha \Big[b(1 - 4\tau_H) - \phi(1 - 3\tau_H - \tau_L) \Big] \right\}$,

and $c_2 = -\frac{1}{2}\phi(b + \phi)\gamma W_0^2 \alpha^2 (1 - 4\tau_L)$.

Proof. See the Appendix. ■

The uniqueness of the equilibrium indicates that only one belief regarding everyone's choice is correct ex post. In equilibrium, the threshold manager's skill level makes her exactly indifferent between the two contracts. The gap between her expected information gains from team- and single-management contracts is just offset by the gap in fixed salary. Any manager with information precision lower than the threshold manager would voluntarily choose the team contract, knowing their teammate also comes from such a subset of the manager pool. Any manager whose ability is better than the threshold manager would voluntarily choose the single-management contract, and knows other relatively better managers would do the same. For each team managed fund in the family, two managers' information precision levels are randomly drawn from the lower sub-pool.

Such an separating equilibrium is stable. Suppose some managers with precision lower than τ_* mistakenly believe that they should choose the single-management contract. Then among these managers, the one with lowest precision would find out that the team contract can make her better off, and turn to it. Subsequently, all of these managers, from low ability to high ability, would do the same and the equilibrium is established. Alternatively, if some managers with precision higher than τ_* intend to choose the team contract, with similar reasoning, from the highest-skilled manager to the lowest-skilled manager within this group, they would sequentially realize that a deviation to the single-management contract is a rational choice.

A pair of fixed salaries $\{a_S, a_T\}$ is of great importance for the equilibrium in the manager pool. The difference between the two fixed salary levels, $a_T - a_S$, determines managers' equilibrium choice. Relative to a_T, when a_S is large enough and go beyond a cutoff c_2, every manager will be attracted to choose the single-management contract. On the other hand, if a_S is smaller than $a_T + c_2$, all managers prefer to team. Both cutoff levels c_1 and c_2 are dependent on the magnitude of risk sharing according to parameter ϕ.

Note that c_2 is always positive. It implies that when the same fixed salary is offered to both contracts, the manager with lowest signal precision will always choose the team-management contract. However, the sign of c_1 is undetermined. If $c_1 > 0$, all managers choose the team-management contract when $a_S = a_T$. Otherwise, there are both types of funds given the same fixed salary./

2.3 Fund Family: Mechanism Design and Separation Policy

The fund family cannot choose the type of a new fund it is going to start. Fund type is determined by new managers' contract choice. Nonetheless, as a mechanism designer, the family can choose contract parameter values to manipulate the self-selection of managers, and thus fund types and its own prospective profit. In this section, we analyze how rational fund family makes decision on compensation contracts and the implications on its organizational structure.

2.3.1 Fund Family's Profit Accounting

Instead of fund performance, the fund family cares about expected profit from hiring a new manager. Expectation is calculated by averaging over multiple layers of partitions in the probability space. First, contract choice and fund type is dependent on the skill level of new manager randomly drawn from the pool at $t = 0$. Skill level also determines precision ofsignals. Second, given fund type and managerial skill,the manager receives a random signal at $t = 1$ and trade accordingly. Third, given signal realizations, excess return at $t = 2$ is also stochastic. We calculate such an ex ante expectation as follows.

For a single-manager fund j managed by manager i, fund family's profit $\tilde{\pi}_{i,S}$ is the difference between its revenue and managerial compensation:

$$\tilde{\pi}_{i,S}(a_S, a_T, \phi; \tilde{\tau}_i) = \tilde{F}_{j,S} - \tilde{f}_{i,S}. \tag{23}$$

Insert fund family revenue (10) and manager compensation (12) into it, we have

$$\tilde{\pi}_{i,S}(a_S, a_T, \phi; \tilde{\tau}_i) = AW_0 - a_S + (B - b)W_0\tilde{R}_i + CW_0^2\tilde{R}_i^2. \tag{24}$$

By law of iterated expectations, given $\tilde{\tau}_i$, expected value of (23) over conditional returns and realization of signals is

$$E\left[\tilde{\pi}_{i,S}(a_S, a_T, \phi; \tilde{\tau}_i)\right] = AW_0 - a_S + (B - b)W_0E\big[E\big(\tilde{R}_i|\tilde{s}_i\big)\big] + CW_0E\big[E\big(\tilde{R}_i^2|\tilde{s}_i\big)\big], \tag{25}$$

which can be reduced to

$$E\left[\tilde{\pi}_{i,S}(a_S, a_T, \phi; \tilde{\tau}_i)\right] = AW_0 - a_S + (B - b)W_0\sqrt{\tilde{\tau}_i}\alpha + \frac{1}{2}CW_0\alpha^2. \tag{26}$$

Expected profit per team manager is calculated in a similar way. For a fund j team-managed by manager i and manager $-i$, profit per manager is

$$\tilde{\pi}_{i,T}(a_S, a_T, \phi; \tilde{\tau}_i, \tilde{\tau}_{-i}) = \frac{1}{2}\left[\tilde{F}_{j,T} - (\tilde{f}_{i,T} + \tilde{f}_{-i,T})\right] \tag{27}$$

Insert family revenue (10) and manager compensation (13) into it,

$$\tilde{\pi}_{i,T}(a_S, a_T, \phi; \tilde{\tau}_i, \tilde{\tau}_{-i}) = AW_0 - a_T + \frac{1}{2}(B - b)W_0(\tilde{R}_i + \tilde{R}_{-i}) + \frac{1}{4}CW_0(\tilde{R}_i + \tilde{R}_{-i})^2 \tag{28}$$

Given precision levels $\tilde{\tau}_i$ and $\tilde{\tau}_{-i}$, expected value of it is

$$E\left[\tilde{\pi}_{i,T}(a_S, a_T, \phi; \tilde{\tau}_i, \tilde{\tau}_{-i})\right] = AW_0 - a_T + \frac{1}{2}(B-b)W_0 \left\{E\big[E\big(\tilde{R}_i|\tilde{s}_i\big)\big] + E\big[E\big(\tilde{R}_{-i}|\tilde{s}_{-i}\big)\big]\right\} \\ + \frac{1}{4}CW_0 E\left\{E\big[(\tilde{R}_i + \tilde{R}_{-i})^2|\tilde{s}_i, \tilde{s}_{-i}\big]\right\}, \tag{29}$$

which can be reduced to

$$E\left[\tilde{\pi}_{i,T}(a_S, a_T, \phi; \tilde{\tau}_i, \tilde{\tau}_{-i})\right] = AW_0 - a_T + \frac{1}{2}(B-b)W_0(\sqrt{\tilde{\tau}_i} + \sqrt{\tilde{\tau}_{-i}})\alpha + \frac{1}{4}CW_0(1 + 2\sqrt{\tilde{\tau}_i\tilde{\tau}_{-i}})\alpha^2. \tag{30}$$

In expressions of $E\left[\tilde{\pi}_{i,S}(a_S, a_T, \phi; \tilde{\tau}_i)\right]$ and $E\left[\tilde{\pi}_{i,T}(a_S, a_T, \phi; \tilde{\tau}_i, \tilde{\tau}_{-i})\right]$, first two terms are family's fee income from current AUM and manager's fixed salary. Other terms are related to fund excess returns and investor inflows. Fund family keeps the rest of linear component of flow-benefits, after paying a fraction to managers, and all of convex component.

Lemma 2 *For two arbitrary managers from Ω with precision $\tilde{\tau}_i, \tilde{\tau}_{-i}$, fund family's expected flow-benefits are always better if they manage two single funds than one team-managed fund.*

Proof. See the Appendix. ■

Everything else equal, the fund family prefers to set up two single-manager funds instead of a team fund. This is because when two managers' sub-portfolio are independent, excess returns of a team-managed fund is diversified. Therefore, single-manager funds can better capture the convexity of investor flows. As a result, the fund family has no incentive to raise a_T, given other contract parameters, to make team-management contract more attractive for managers. This intuition will be useful in the proof of the contact choice of ϕ.

2.3.2 Expected Profit Per Manager

When the fund family is making contract decisions, it does not know the managerial skill of a new manager. However, it knows the probability distribution of skill, given contract choice of the new manager. To analyze the decision on contract parameters, we first calculate the expected profit from a new manager, given her skill. This is done in equations 26 and 30.

Now we can compute ex ante expected profit per manager by taking expectations over subsets of Ω

where managers in single-manager and team-managed funds are drawn from, respectively. Averaging $E[\tilde{\pi}_{i,S}(a_S, a_T, \phi; \tilde{\tau}_i)]$ and $E[\tilde{\pi}_{i,T}(a_S, a_T, \phi; \tilde{\tau}_i, \tilde{\tau}_{-i})]$ over manager's precision gives ex ante expected profit from a new manager. That is,

$$E[\tilde{\pi}_{i,S}(a_S, a_T, \phi)] = \int_{\tilde{\tau}_i \in \Gamma} E[\tilde{\pi}_{i,S}(a_S, a_T, \phi; \tilde{\tau}_i)] \, pdf(\tilde{\tau}_i | \tilde{\tau}_i \in \Gamma) d\tilde{\tau}_i, \tag{31}$$

and

$$E[\tilde{\pi}_{i,T}(a_S, a_T, \phi)] = \iint_{\tilde{\tau}_i, \tilde{\tau}_{-i} \in \Gamma^c} E[\tilde{\pi}_{i,T}(a_S, a_T, \phi; \tilde{\tau}_i, \tilde{\tau}_{-i})] \, pdf(\tilde{\tau}_i, \tilde{\tau}_{-i} | \tilde{\tau}_i, \tilde{\tau}_{-i} \in \Gamma^c) d\tilde{\tau}_i d\tilde{\tau}_{-i}, \tag{32}$$

where Γ^c is the complement set of Γ in the manager pool: $\Gamma^c = \{i : i \in \Omega \ \& \ i \notin \Gamma\}$.

Finally, average expectation of profit per manager, weighted by probability of contract choices of a new manager, is the direct objective function for the fund family to maximize. Given an equilibrium in the manager pool where managers in Γ and Γ^c self-select into single-manager and team-managed funds, the fund family's problem is

$$\underset{\{a_S, a_T, \phi\}}{Max} \ \Pi = \Pr(i \in \Gamma) E[\tilde{\pi}_{i,S}(a_S, a_T, \phi)] + \Pr(i \in \Gamma^c) E[\tilde{\pi}_{i,T}(a_S, a_T, \phi)], \tag{33}$$

where $\Pr(\cdot)$ is probability of drawing a manager from either subset of Ω.

2.3.3 Fund Family's Contract Choice

After paying managers' compensation, the fund family keeps the rest of their management fees from investors as profits. In this sense, the decision is straightforward: the more revenue collected and the less compensation paid, the better. By assumption, management fees based on current assets under management is constant. When flow-performance is linear, the fund family design contracts simply to keep some rents from managers' skills. Besides, as we have shown earlier, single-manager funds on average deliver better money inflows than team-managed funds when the relationship is convex. This fact creates an incentive for the fund family to induce more single-manager funds. Moreover, as threshold $\tau_*(a_S, a_T, \phi)$ varies with three parameters, the fund family's costs also change in inducing different managers to choose its desired contracts. Unlike ϕ, fixed salary a_S and a_T are costly. As a result, the fund family's equilibrium contract choice is based on the tradeoff among keeping rents from talents, capturing convex flows, and saving costs.

We define the fund family's equilibrium contract choice as follows.

Definition 2 (Optimal Contract) *An equilibrium of the contracting problem between the fund family and managers in the labor pool is a set of parameters* $\{a_S, a_T, \phi\}$*, for single- and team-management contracts, such that*

1) *Given* $\{a_S, a_T, \phi\}$*, managers' contract choices constitute a Perfect-Bayesian Nash Equilibrium, with a threshold skill level* $\tau_*(a_S, a_T, \phi)$*;*

2) *Parameters* $\{a_S, a_T, \phi\}$ *satisfy manager's incentive rationality condition:*

   for $\forall i \in \Omega$*,* $\max\left\{E(U_{i,S}), E(U_{i,T})\right\} \geqslant \underline{U}$ *regardless of the contract choice of* $\forall i' \neq i$ *;*

3) *Given fund flow convexity coefficient* C*, parameters* $\{a_S, a_T, \phi\}$ *solve the fund family's expected profit maximization problem (33):*

$$\underset{\{a_S, a_T, \phi\}}{Max}\ \Pi = \Pr(i \in \Gamma)E\left[\tilde{\pi}_{i,S}(a_S, a_T, \phi)\right] + \Pr(i \in \Gamma^c)E\left[\tilde{\pi}_{i,T}(a_S, a_T, \phi)\right].$$

In the former section, we have shown the uniqueness of pure-strategy Bayesian Nash Equilibrium. However, Proposition 1 is based on a case $\phi < 0$, which means the fund family offers risk sharing for teammates. Now we show it is the only non-trivial case.

Proposition 2 *The fund family will always impose a risk sharing rule (*$\phi < 0$*) for the team-management contract.*

Proof. See the Appendix. ■

Risk sharing rule within teams improves welfare of risk-averse managers, and the fund family can pay less fixed salary to them while keeping their participation constraint. In contrast, relative performance burns welfare in the economy. Given advantage of single-managed funds in capturing flows, for the fund family, any choice of $\phi > 0$ is (at least weakly) dominated by effectively offering only single contract ($\phi = 0$).

Corollary 2.1 *In equilibrium, managers with skill $\tau_i \in \Gamma = [\tau_L, \tau_*]$ choose team-management contract, and managers with skill $\tau_i \in [\tau_*, \tau_H]$ choose single-management contact.*

Proof. This is a ready result following Lemma 1 and Proposition ■

To further characterize the fund family's equilibrium choice of contract parameters, we establish three intuitive and useful lemmas.

Lemma 3 (Monotonicity) *Equilibrium threshold manager's precision level $\tau_*(a_S, a_T, \phi)$ is always (weakly) monotone in fixed salary a_S and a_T when $\phi < 0$. Specifically, τ_* decreases in a_S, and increases in a_T.*

Proof. See the Appendix. ■

Variations in fixed salaries change relative attractiveness of the two contracts. The higher the salary of one contract is compared to the other, the more attractive that contract will be for any manager in the pool. So values of the two fixed salaries, $\{a_S, a_T\}$, serve as a policy tool for the fund family to induce desired separation of managers. For example, when a_T increases marginally relative to a_S, the manager whose skill is just a little bit better than the original τ_*, who used to choose the single-management contract, will now turn to the team-management contract. In this way, the fund family can indirectly manipulate proportions of its new team and single-managed funds by change the fixed salary offered in contracts.

Corollary 2.2 *Given ϕ and a_T, $a_S(\tau_*)$ is the inverse function of $\tau_*(a_S, a_T, \phi)$.*

Proof. This is a ready result from Lemma 3. ■

Intuitively, when ϕ and a_T are fixed, the fund family directly chooses a_S to indirectly choose τ_*. So we can interpret as that the family chooses τ_* in the optimization process, and each choice of τ_* corresponds to a unique value of a_S, which must be implemented in order to reach that target τ_*. With the natural lower and upper bounds of τ_*, τ_L and τ_H, we can prove our later results more conveniently.

Lemma 4 *Given ϕ, the fund family's optimal choice of a_T solves*

$$a_T + bW_0\alpha\sqrt{\tau_L} - \frac{1}{4}\gamma\left[(b+\phi)^2 + \phi^2\right]W_0^2\alpha^2(1-4\tau_L) = \underline{U}. \tag{34}$$

The fund family would set a_T as low as possible, since no benefit is associated with a higher a_T as implied by the combination of Lemma 2 and Lemma 3. More skilled managers always get more rents from their own skills, and they are always better off ex ante than less skilled managers. As we have shown in Proposition 1, when risk sharing is offered, the manager with the lowest signal precision is most incentivized to team. In equilibrium, the fund family would set fixed salary a_T such that the least skilled manager is exactly kept at reservation utility $\underline{U}$. Given our assumption on the participation condition, a limiting condition is that two managers, both with signal precision τ_L, can get reservation utility if they form a team.

The choice of a_T above keeps the least-skilled manager exactly at reservation utility. This is the smallest value of a_T that satisfies the participation condition for all managers. Such an a_T is independent of a_S. When a_S is raised, some managers deviate to the single-management contract. Remaining managers, who still prefer to team, are still paid with a_T, though they will have a lower expectation for their future teammate's skill.

Note that in equation (4), optimal choice of a_T decreases in value of parameter ϕ for any $\phi \in [-\frac{b}{2}, 0)$. This is because the worst manager's welfare improves as the magnitude of risk sharing increases. In the following proposition, we show that the fund family will choose a specific value for parameter ϕ.

Proposition 3 *The fund family's optimal choice is $\phi = -\frac{b}{2}$.*

Proof. See the Appendix. ■

As we have shown, risk sharing policy is beneficial for both managers and the fund family. Moreover, more generous risk sharing saves more fixed salary paid out. In equilibrium, the fund family chooses to impose a risk sharing rule with largest magnitude. By doing that, the family can always induce any equilibrium separation with less costs. Thus, $\phi = -\frac{b}{2}$ is the best choice for the fund family. Though different choices of ϕ induces different equilibrium profit expectations, any other equilibrium revenue prospect can be replicated in a cheaper way with $\phi = -\frac{b}{2}$.

The manager with precision τ_L can never team with a manager with skill inferior to her. However, the more skilled a manager is, the more concerned she might be about teaming and sharing risk with a low-skilled teammate, which may harm her own welfare.

With Lemma 4, a_T is fixed when $\phi = -\frac{b}{2}$. For convenience, from now on, we rewrite the threshold manager's precision level and expected profit per manager as univariate functions of a_S:

$$\tau_*(a_S) = \tau_*(a_S, a_T, -\frac{b}{2}), \tag{35}$$

$$E\left[\tilde{\pi}_{i,S}(a_S)\right] = E\left[\tilde{\pi}_{i,S}(a_S, a_T, -\frac{b}{2})\right], \tag{36}$$

and

$$E\left[\tilde{\pi}_{i,T}(a_S)\right] = E\left[\tilde{\pi}_{i,T}(a_S, a_T, -\frac{b}{2})\right]. \tag{37}$$

Meanwhile, inverse function of $\tau_*(a_S)$ in Corollary (2.2) can be simply rewritten as $a_S(\tau_*)$.

The choice of a_S is critical in the fund family's optimization problem. On the one hand, it is the cost of fixed salary paid to any manager that chooses the single-management contract. On the other hand, it changes managers' equilibrium choices of contract and organizational structure within the fund family. The following proposition identifies flow-convexity's effect on the fund family's contract choice and organizational structures.

Proposition 4 *1) When future inflows are linear in fund excess returns, when $c_1 < 0$, equilibrium $\tau_* \in (\tau_L, \tau_H)$; when $c_1 \geqslant 0$, $\tau_* = \tau_H$.*

2) When flows are convex in fund excess returns, as long as convexity is not extremely large, (i.e. $C < \frac{4b}{3\alpha}$), equilibrium threshold manager's signal precision decreases in family convexity *coefficient:*

$$\frac{\partial \tau_*}{\partial C} < 0.$$

Proof. See the Appendix. ■

When flows are linear in fund returns, the fund family has no incentive to pay more fixed salary to a single-fund manager. Future flows depend only on the manager's skill and luck, and are independent of management structure of funds. Thus, the fund family's expected profit maximization problem is reduced to a simple cost minimization problem.

When some better skilled managers prefer to work alone, setting a lower fixed salary for the single-management contract reduces the cost of hiring them. By doing that, the fund family can extract some rents from these managers' skill. If $c_1 < 0$, some managers prefer single-management contract if $a_S = a_T$. In this case, lowering a_S simultaneously pushes more managers to choose the team-management contract, but total costs are lower. However, setting a very low a_S, such that all managers prefer to team, is also unwise. If that happens, the fund family has to pay every manager a_T and cannot extract any rent from managerial skill of better managers.

Adding flow convexity into the model complicates the decision. The team-management contract serves as a shelter for less-skilled managers. With a risk sharing rule, they can be paid with less fixed salary. But the diversification effect within a team can compromise investors' cash flows rewarding funds with superior excess returns.

The fund family faces a tradeoff between lower costs and better future inflows when the convexity term is of a reasonable scale, and $C < \frac{3b}{4\alpha}$ is a loose sufficient condition for that. As τ_* increases, the subset of two team managers improves, and flow-benefits for the family increases very fast in speed if convexity is too large. However, absolute size of that cross-term is small compared with single-manager funds, and we need a sufficient condition simply to avoid exaggerating the benefit from multiple managers in team-managed funds.

The more convex the relationship between excess returns and fund flows is, the more the fund family is willing to hire managers to run single-manager funds despite larger costs associated with the separation policy. As a result, we expect to see a larger fraction of team-management for a fund family with less convex inflows.

2.4 Fund Level Performance: Risk and Returns

The fund family chooses fixed salary in their compensation contracts to separate managers with heterogenous managerial skill into single-manager and team-managed funds. Although the same manager pool is shared, separation policy affect individual funds' performance within and across families.

Before comparing performance at both manager and fund levels, we highlight two features of the performance measure in the model. Firstly, when uncertainty in excess returns is accounted for, performance is an univariate increasing function of manager ability.

Lemma 5 *At manager level, risk adjusted rate of return, IR_i, is independent of α. Given the manager's signal precision τ_i,*

$$IR_i = \sqrt{\frac{2\tau_i}{1 - 2\tau_i}}. \tag{38}$$

Proof. See the Appendix. ■

Managerial skill is critical for portfolio Information Ratio. When a manager implements a trading strategy, expected excess return and risk of her portfolio increases with the same magnitude. However, uncertainty of the trading strategy does not affect Information Ratio. When excess return is more volatile, conditional on manager's private signal, portfolio risk is larger, but expected return is also larger and the two effects are of the same order. As a manager's signal precision improves, her portfolio expected excess return increases while conditional risk decreases. The more skilled a manager is, a better performance we expect at manager level.

Secondly, team-managed funds benefit from the diversification of team managers' signal realizations and sub-portfolio excess returns.

Lemma 6 *At fund level, if all managers have the same managerial skill τ_i, we have*

$$IR_j^T = \sqrt{2}\, IR_j^S. \tag{39}$$

Proof. See the Appendix. ■

When managers are homogenous in managerial skill, team management is more than a perfect remedy for decreasing return to scale at manager level. Team managers can deliver the same expected excess return in portfolios they manage, and uncorrelated signals and excess returns further contribute to a reduction in fund level risk.

Nonetheless, in equilibrium, single-manager funds are managed by relatively more skilled managers. From Lemma 5, manager level performance is solely determined by the manager's skill level. In this sense, single-manager funds are advantageous at delivering better performance. From Lemma 6 , team funds have better fund level performance when managers are equally skilled, due to diversification within teams. The actual relative performance between single-manager and team-managed funds is a result of the combination of these two effects. Threshold level of signal precision matters. When τ_* increases, average signal precision of managers in single and team-managed funds improves, and the probability of hiring a new team manager increases.

2.4.1 Within the Fund Family: Single v.s. Team

Within the fund family, which type of funds on average outperforms the other? As we have shown, only two factors should be considered: managerial skill and team diversification.

On one hand, single-managed funds are managed by more skilled managers. This means, single-managed funds have advantage on expected excess returns, which is linear and solely dependent on signal precision. To see this, consider one single-manager and one team-managed funds randomly drawn from the fund family. Ex ante expected excess returns are

$$E(\tilde{R}_j^S) = E\big[E(\tilde{R}_j^S|\tilde{\tau}_i)|\tilde{\tau}_i \in [\tau_*, \tau_H]\big], \tag{40}$$

and

$$E(\tilde{R}_j^T) = E\big[E(\tilde{R}_j^T|\tilde{\tau}_i, \tilde{\tau}_{-i})|\tilde{\tau}_i, \tilde{\tau}_{-i} \in [\tau_L, \tau_*]\big]. \tag{41}$$

Their difference can be reduced to

$$E(\tilde{R}_j^S) - E(\tilde{R}_j^T) = \frac{\sqrt{\tau_H \tau_L}(\sqrt{\tau_H} - \sqrt{\tau_L}) + \sqrt{\tau_*}(\tau_H - \tau_L)}{(\sqrt{\tau_H} + \sqrt{\tau_*})(\sqrt{\tau_*} + \sqrt{\tau_L})}, \tag{42}$$

which is always positive.

On the other hand, team-managed funds benefit from diversification of managers' independent signals and strategy excess returns. Even though managed by less skilled managers, it is possible that team-managed funds have lower fund level uncertainty in excess returns.

Comparison of Information Ratio between two fund management structures depends on which factor dominates in the determination of fund level risk. If team diversification dominates effect of different skill levels, team-managed funds have lower risk. Moreover, if the risk is lower enough to overwhelm single-management's advantage in expected excess returns, then team-managed funds can possibly outperform single-managed funds on average. In our model, the result is undetermined and sensitive to constant parameter values.

2.4.2 Performance Across Fund Families

If fund families are heterogenous in the convexity of their money inflows, as Proposition 4 shows, they will have different threshold in the separation of single and team managers. The next proposition gives implications of different thresholds on fund level performance across fund families.

Proposition 5 *Across fund families, a fund family with larger equilibrium threshold τ_* expects*

1) Higher expected excess return, lower volatility and better performance for its single-managed funds;

2) Higher expected excess return, lower volatility and better performance for its team-managed funds.

Proof. See the Appendix. ■

When more managers in the pool prefer the team-management contract, average precision levels for both team and single managers increase. We have shown that when funds with the same management structure are compared, the only factor matters for performance is managerial skill. Thus, sibling funds belong to a fund family with larger fraction of team managers tend to have higher expected excess return, lower risk and of course better average performance measured by Information Ratio.

3 Empirical Predictions

Our model yields the following testable predictions.

Hypothesis 1 (H1) *Fund families with more convex flows have smaller fractions of team funds.*

Hypothesis 2 (H2) *Within each family, team fund managers have worse skills than managers in single-manager funds.*

Hypothesis 3 (H3) *Across families, controlling for family performance, team fund managers in more convex families have worse skills than team fund managers in less convex families; and stand-alone managers in more convex families have worse skills than stand-alone managers in less convex families.*

4 Empirical Results

We test these hypotheses in this section using a sample of actively managed U.S. domestic equity funds from the Center for Research in Security Prices (CRSP) Mutual Fund Database.

4.1 Data

We obtain our data from several sources. We take fund names, returns, total net assets (TNA), expense ratios, investment objectives, and other fund characteristics from CRSP Survivorship Bias Free Mutual Fund Database. The CRSP mutual fund database lists multiple share classes separately. We obtain mutual fund portfolio holdings from the Thomson Reuters Mutual Fund Holdings (formerly CDA/Spectrum S12) database. The database contains quarterly portfolio holdings for all U.S.

equity mutual funds. We merge the CRSP Mutual Fund database and the Thomson Reuters Mutual Fund Holdings database using the MFLINKS table available on WRDS (see Wermers (2000)).

We examine actively-managed U.S. equity mutual funds from January 1992 to December 2012. Our sample period starts in January 1992 as information about fund family is available in CRSP Mutual Fund data since then. We exclude balanced, bond, sector, index, and international funds.[4] We identify and exclude index funds using their names and CRSP index fund identifier.[5] To be included in the sample, a fund's average percentage of stocks in the portfolio as reported by CRSP must be at least 70 percent or missing. Following Elton, Gruber, and Blake (2001), Chen, Hong, Huang, and Kubik (2004), and Yan (2008), we exclude funds with less than $15 million in TNA. We further eliminate observations before the fund's starting date reported by CRSP to address incubation bias (Evans (2010)). Our final sample consists of 3,288 unique actively-managed U.S. equity mutual funds and 422,831 fund-month observations.

4.2 Variable Construction

To measure performance, we compute alphas using the Carhart (1997) four-factor model, which adjusts for excess market return (Mktrf), size (SMB), book-to-market (HML), and momentum (UMD) factors. Specifically, we first estimate the factor loadings using the preceding 24 monthly fund net returns. We require a minimum of 12 monthly observations in our estimation. We then calculate monthly out-of-sample alpha as the difference between a fund's net return in a given month and the sum of the product of the estimated factor loadings and the factor returns during that month.

In addition to the four-factor alpha measure, we employ several variables to capture the activeness

[4] Similar to prior studies (e.g., Kacperczyk, Sialm, and Zheng (2008)), we base our selection criteria on objective codes and on disclosed asset compositions. First, we select funds with the following Lipper classification codes: EIEI, G, LCCE, LCGE, LCVE, MCCE, MCGE, MCVE, MLCE, MLGE, MLVE, SCCE, SCGE, or SCVE. If a fund does not have a Lipper Classification code, we select funds with Strategic Insight objectives AGG, GMC, GRI, GRO, ING, or SCG. If neither the Strategic Insight nor the Lipper objective is available, we use the Wiesenberger Fund Type Code and select funds with objectives G, G-I, AGG, GCI, GRI, GRO, LTG, MCG, or SCG. If none of these objectives is available, we keep a fund if it has a CS policy (i.e., the fund holds mainly common stocks). Further, we exclude funds that have the following Investment Objective Codes in the Thomson Reuters Mutual Fund Holdings database: International, Municipal Bonds, Bond and Preferred, Balanced, and Metals.

[5] Similar to Busse and Tong (2012) and Ferson and Lin (2014), we exclude from our sample funds whose names contain any of the following text strings: Index, Ind, Idx, Indx, Mkt,Market, Composite, S&P, SP, Russell, Nasdaq, DJ, Dow, Jones, Wilshire, NYSE, iShares, SPDR, HOLDRs, ETF, Exchange-Traded Fund, PowerShares, StreetTRACKS, 100, 400, 500, 600, 1000, 1500, 2000, 3000, 5000. We also remove funds with CRSP index fund flag equal to D (pure index fund) or E (enhanced index fund).

of fund managers' portfolio management: (i) active share (Cremers and Petajisto (2009)), (ii) return gap (Kacperczyk, Sialm, and Zheng (2008)), and (iii) industry concentration (Kacperczyk, Sialm, and Zheng (2005)). First, active share captures the percentage of a manager's portfolio that differs from its benchmark index. It is calculated by aggregating the absolute differences between the weight of a portfolio's actual holdings and the weight of its closest matching index. Second, return gap measures the difference between fund gross returns and holdings-based returns. We compute gross fund returns by adding one-twelfth of the year-end expense ratio to the monthly net fund returns during the year. We calculate the holdings-based gross portfolio return each month as the return of the disclosed portfolio by assuming constant fund portfolio holdings from the end of the previous quarter. Finally, we compute industry concentration index as the sum of the squared deviations of the value weights for each industry held by the mutual fund, relative to the industry weights of the total stock market.

Team fund is an indicator variable that equals to one if the fund is managed by a team of portfolio managers based on CRSP mutual fund data and zero otherwise. Fund TNA is the sum of portfolio assets across all share classes of a fund. Fund Age is the age of the oldest share class in the fund. Family TNA is the aggregate total assets under management of each fund in a fund family (excluding the fund itself). Expense Ratio is the average expense ratio value-weighted across all fund share classes. Turnover ratio is defined as the minimum of sales or purchases divided by total net assets of the fund. Fund flow is calculated as the average monthly net growth in fund assets beyond capital gains and dividends (e.g., Sirri and Tufano (1998)). We report the summary statistics of all variables discussed above in Table 1.

4.3 Empirical Results

4.3.1 Fraction of Team Funds and Flow Convexity

In this section, we test our model's prediction (H1) regarding the relation between family flow convexity and percentage of team funds. Following the insight from Huang, Wei, and Yan (2007) that small fund families have a more convex flow-performance relation compared to large families, we use fund family size as our main proxy for flow convexity. We then test hypothesis H1 that families with more convex flow compensation (i.e., small size families) have lower percentage of team funds.

We first use our sample to verify the previous finding that small fund families have higher flow convexity. Following Huang, Wei, and Yan (2007), we use a piecewise linear regression to analyze flow convexity. In particular, each month, we assign funds' fractional performance ranks from zero to one based on their past 12-month net returns relative to other funds with similar investment objectives, or based on their four-factor alphas during the past 24 months. The fractional rank for funds in the bottom performance quintile (Low) is defined as $\min(Rank, 0.2)$. Funds in the three medium performance quintiles (Mid) are grouped together and receive ranks that are defined as $\min(0.6, Rank - Low)$. The rank for the top performance quintile (High) is defined as Rank - Mid - Low. Each month a piecewise linear regression is performed by regressing monthly flows on lagged funds' fractional performance rankings over the low, medium, and high performance ranges, their interaction terms with an indicator variable (Large Family) that equals one if the fund belongs to a family whose size is above median value and zero otherwise. The control variables include aggregate flow into the fund objective category, fund size, fund age, team fund dummy, expense ratio, turnover ratio, volatility of monthly returns during past 12 month.

Table 2 reports the time series average of the monthly coefficient estimates and Fama and MacBeth (1973) t-statistics adjusting standard errors using the Newey and West (1987) correction with 12 lags. Fractional performance ranks are based on past 12-month net returns in columns (1) and (2) and based on four-factor alphas in columns (3) and (4). First, the coefficient estimate of High is significantly larger compared to the coefficient of Low or Mid in columns (1) and (3). It suggests that the flow-performance relation is convex, consistent with prior studies such as Chevalier and Ellison (1997) and Sirri and Tufano (1998). Second, like in Huang, Wei, and Yan (2007), we find that the flow-performance relation is more convex for smaller size families. In particular, in columns (2) and (4), the coefficients of the interaction term between High and Large Family are both significantly negative, while the coefficients of the interaction term between Mid and Large Family are positive. With the above evidence, we use fund family size as the proxy for family flow convexity.

Next, we test hypothesis H1 by analyzing the percentage of team funds across families with difference flow convexity proxied by family size. In particular, in a given month, we calculate for each fund family the percentage of team funds based on the number of funds or fund TNA. Then, we sort fund families into quintiles each month based on lagged family size and calculate the time series average of the percentage of team funds for each of the family size quintiles. We also test the difference in team fund percentage between the smallest and largest family size quintiles and adjust standard errors using the Newey and West (1987) correction with 12 lags. Table 3 presents the results. Consistent with hypothesis H1, we find that small families (i.e., the ones with more convex flow compensation) have lower percentage of team funds compared to large families. In particular, the average percentage of team funds is 54% based on number of funds for largest family size quintile (Q5). In contrast, the corresponding percentage of team funds for smallest family size quintile is 40.7%, with a difference of 13.3% being both statically and economically significant. We find similar evidence if we compute the percentage of team funds based on fund TNA, rather than number of funds.

In Figure 2, we plot the yearly averages of the percentage of team funds in the smallest and largest family size quintiles (Q1 and Q5) over the entire sample period. The percentage of team funds is calculated using the number of funds in Panel (a) and fund TNA in Panel (b). In both panels, we find that small families of Q1 have lower percentage of team funds compared to large families of Q5 in 20 out of the 21 years.

We further plot the time series of the convexity of the flow-performance relation in Figure 3. In particular, Panels (a) and (b) plot the 2-year moving averages of the monthly coefficient estimates of Low, Mid, and High based on the results in Table 2 columns (1) and (3), respectively. Similar to Kim (2014), we find a clear decreasing trend over time in the convexity of the flow-performance relation over the period from 1992 to 2012 in the U.S. mutual fund industry. This decreasing trend in convexity coincides with the increasing trend in the percentage of team funds as shown in Figure 1 Panels (a) and (b), which is also broadly consistent with the hypothesis H1 that associates less flow convexity with higher percentage of team funds.

4.3.2 Team vs. Single-Manager Funds within Family

In this section, we test our model's prediction (H2) that, within each family, team fund managers have worse skills than managers in single-manager funds. In particular, we run Fama-MacBeth regressions of monthly fund performance or portfolio activeness measure on the team fund dummy with family fixed effects:

$$Y_{i,j,t} = \alpha + \beta \, \text{TeamFund}_{i,j,t-1} + \gamma X_{i,j,t-1} + f_j + \epsilon_{i,j,t}, \tag{43}$$

where $Y_{i,j,t}$ refers to fund i's performance or portfolio management activeness as measured by active share, return gap, or industry concentration index; $\text{TeamFund}_{i,j,t-1}$ is a dummy variable that takes the value of one if the fund is a team fund and zero otherwise; f_j refers to family fixed effects. The control variables $X_{i,j,t-1}$ include lagged family size dummies, fund size, fund age, expense ratio, fund flow, turnover ratio, and fund net return. Table 4 reports the estimation results on fund performance. We analyze fund net return in columns (1) and (2) and four-factor alpha in columns (3) and (4). Consistent with our model's prediction H2, we find that team funds underperform single-manager funds within family. In columns (2) and (4) that include control variables, the coefficient estimates of team fund dummy are both negative and significant at the 5% level. In terms of economic significance, based on the results in column (4), team funds underperform single-manager funds within family by 30.1 basis points per annum as measured by four-factor alpha.

Table 5 reports the estimation results on active share, return gap, and industry concentration. Consistent with our model's prediction H2, we find that within family team funds are less active in managing their portfolios compared to single-manager funds. The coefficient estimates of team fund dummy are all negative, significant in four of six specifications. It suggests that team fund managers are less active in deviating from benchmarks and holding concentrated portfolios. In summary, the evidence in Tables 4 and 5 supports to our model's prediction that, within family, team fund managers have worse skills than managers in single-manager funds.

We further examine the difference in volatility of alpha and information ratio for team vs. single-manager funds. Each year we calculate the average of monthly four-factor alphas, volatility (i.e., standard deviation) of alpha, and information ratio (i.e., alpha mean over its standard deviation). We then run yearly Fama-MacBeth regressions of these three variables on team fund dummy and other controls with family fixed effects. Table 6 reports the estimation results. First, consistent with Table 4, the results in columns (1) and (2) show that team funds underperform single-manager funds within family. Second, we find that team funds exhibit lower risk compared to single-manager funds as measured by volatility of alpha as shown in columns (3) and (4). Third, team funds also have lower information ratio compared to single-manager funds within family as shown in columns (5) and (6), which suggests that the effect of team management on alpha dominates the effect on volatility of alpha.

4.3.3 Fund Performance and Activeness across families

In this section, we test our model's prediction (H3) that, across families, team fund and stand-alone managers in families with more convex flows have worse skills than their counterparts in less convex families, respectively. To conduct an across-family analysis, we run Fama-MacBeth regressions of monthly fund performance or portfolio activeness measure on the family flow convexity proxy (i.e., two family size dummies). We include control variables such as lagged family size dummies, fund size, fund age, expense ratio, fund flow, turnover ratio, and fund net return. To alleviate the potential concern that certain families (e.g., larger size ones) attract more talented managers, we further control for the average performance or portfolio activeness of all funds in the family excluding the fund itself in our main regressions. Table 7 reports the estimation results. We analyze single-manager funds in columns (1) and (4), team funds in columns (2) and (5), and all funds in columns (3) and (6). We add family average alpha as an additional control in columns (3) to (6). Consistent with our model's prediction H3, we find that team fund and stand-alone managers in small families (i.e., with more convex flows) underperform their counterparts in large families (i.e., with less convex flows), respectively, after controlling for family performance. In particular, the coefficient estimates of Middle Family and Large Family are positive and significant at the 10% or better in all six specifications. Moreover, the differences between Large Family and Middle Family are all positive, significant in four out of six specifications as shown in the bottom of Table 7.

Next, we examine the activeness of fund managers' portfolio management across families and present the estimation results in Table 8. Our results shows that team fund and stand-alone managers in small families are less active in managing their portfolios compared to their counterparts in large families, respectively, after controlling for the family average of portfolio management activeness. In particular, the coefficient estimates of Middle Family and Large Family are all positive, significant in most specifications. Moreover, the coefficient estimate of Large Family is significantly larger than the one of Middle Family in seven out of nine specifications. This evidence provides further support to our hypothesis H3.

Finally, we examine the across-family difference in volatility of alpha and information ratio for team fund and stand-alone managers, respectively. We report the Fama-MacBeth estimation results in Table 9. Consistent with Table 6, the results in columns (1) to (3) show that team fund and stand-alone managers in small families underperform their counterparts in large families, respectively. We also find that funds in larger families also have higher volatility of alpha. Furthermore, we find that team fund and stand-alone managers in small families have lower information ratio compared their counterparts in large families, respectively, which is also consistent with our model's prediction (H3).

5 Conclusion

We develop a model of delegated portfolio management with two layers of agency problems between investors, fund families and managers. We consider an independent team structure in which each manager has full discretion over their own sub portfolio. Given any two managers, a team fund provides at least as good a performance as the weighted average of two separately-run single-manager funds, with similar mean return and lower variance due to diversification of investment risks and manager skills. However, team funds on average can still underperform single-manager funds.

The reason is that fund families always choose to offer risk sharing contracts within their team funds. Their objective is to maximize their own profit by reducing expected compensation to risk averse managers. As a result, better skilled managers prefer single-manager fund over team fund structure, leading to underperformance of team funds. Thus, fund families' incentive to maximize expected profit yields very different outcome from maximizing fund performance for investors.

We also find that convex compensation for fund families leads to a preference for single-manager funds over team funds, because their expected revenue is higher from two single-manager funds than from a team fund. Therefore, families with more convex compensation optimally choose a lower fraction of team-managed funds and have a lower risk-adjusted performance. An interesting application of this result is the overwhelming popularity of single-manager single-strategy funds for hedge funds, which arguably has the most convex, incentive fee compensation contracts. Hedge fund investors often hold several funds (sometimes issued by the same fund family or even the same fund manager), each focusing on a different strategy and charging a separate option-like compensation. While this payment scheme appears overly expensive for investors, it may not be in the best interest of investors to switch to multi-strategy hedge funds which charge incentive fees only when the combined performance of all strategies is sufficiently high. The reason is that the multi-strategy fund may not generate sufficient revenue to retain the best hedge fund managers in each of the strategies.

Our model yields several testable predictions for empirical study. We use the well-documented fact that small families have more convex fund flows to test our theory and find consistent evidence: First, small fund families have lower fractions of team funds; Second, within each family, team funds have worse performance than single-manager funds; Third, across families, controlling for family performance, team (or single-manager) funds in smaller family perform worse than team (or single-manager) funds in large families.

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A Appendix: Proofs

Proof of Lemma 1

Given a common prior belief, where an arbitrary subset $\Gamma \subset \Omega$ would choose the team-management contract, manager i's ex ante expected utility from that contract can be calculated with equations 17 and 18 :

$$\begin{aligned} E(U_{i,T}) &= a_T + W_0\alpha\left[(b+\phi)\sqrt{\tau_i} - \phi E(\sqrt{\tilde{\tau}_{-i}}|\tilde{\tau}_{-i} \in \Gamma)\right] \\ &- \frac{\gamma W_0^2\alpha^2}{4}\Big\{(b+\phi)^2(1-4\tau_i) + \phi^2\big[1-4E(\tilde{\tau}_{-i}|\tilde{\tau}_{-i} \in \Gamma)\big]\Big\}. \end{aligned} \tag{A1}$$

Subtract 16 from it, we have ex ante utility gap between the two contracts for the manager with τ_i,

$$\begin{aligned} G(\tau_i; a_S, a_T, \phi, \Gamma) &= a_T - a_S + \phi W_0\alpha\sqrt{\tau_i} - \frac{\gamma W_0^2\alpha^2}{4}\phi(\phi+2b)(1-4\tau_i) \\ &- \left[\phi E(\sqrt{\tilde{\tau}_{-i}}|\tilde{\tau}_{-i} \in \Gamma) + \phi^2\Big(1-4E(\tilde{\tau}_{-i}|\tilde{\tau}_{-i} \in \Gamma)\Big)\right] \end{aligned} \tag{A2}$$

where the last term is a constant given Γ. Differentiate $G(\tau_i; a_S, a_T, \phi, \Gamma)$ with respect to τ_i and collect terms,

$$\frac{\partial G(\tau_i; a_S, a_T, \phi, \Gamma)}{\partial \tau_i} = \phi W_0\alpha\left[\frac{1}{2}\tau_i^{-\frac{1}{2}} + \gamma W_0\alpha(\phi+2b)\right]. \tag{A3}$$

Since $\phi \in \left[-\frac{b}{2}, \frac{b}{2}\right]$, we have

$$sign\left[\frac{\partial G(\tau_i; a_S, a_T, \phi, \Gamma)}{\partial \tau_i}\right] = sign(\phi). \tag{A4}$$

It implies that given any equilibrium Γ, utility gap $G(\tau_i; a_S, a_T, \Gamma)$ changes in the manager's skill level monotonically. This completes the proof.

Proof of Proposition 1

(*Uniqueness*) Following Lemma 1, equilibrium subset of team managers, Γ, is endogenous in the threshold skill level τ_*. When $\phi < 0$, we have $\Gamma = [\tau_L, \tau_*]$. Insert it into the utility gap function, and for the threshold manager:

$$\begin{aligned} G(\tau^*; a_S, a_T, \phi, [\tau_L, \tau_*]) &= a_T - a_S + \phi W_0\alpha\left[\sqrt{\tau_*} - E(\sqrt{\tilde{\tau}_{-i}}|\tilde{\tau}_{-i} \in [\tau_L, \tau_*])\right] \\ &- \frac{\gamma W_0^2\alpha^2}{4}\left\{(\phi^2+2b\phi)(1-4\tau_*) + \phi^2\left[1-4E(\tilde{\tau}_{-i}|\tilde{\tau}_{-i} \in [\tau_L, \tau_*])\right]\right\}. \end{aligned} \tag{A5}$$

With the uniform distribution assumption,

$$pdf(\tilde{\tau}_{-i}|\tilde{\tau}_{-i} \in \Gamma = [\tau_L, \tau_*]) = \frac{1}{\tau_* - \tau_L}. \tag{A6}$$

Apply the probability density function A6 in (A5), differentiate G with respect to τ_*, and collect terms,

$$\frac{\partial G(\tau_*; a_S, a_T, \phi, [\tau_L, \tau_*])}{\partial \tau_*} = \frac{1}{6}\phi W_0 \alpha \left[\frac{\tau_* + 2\sqrt{\tau_* \tau_L} + 3\tau_L}{\sqrt{\tau_*}(\sqrt{\tau_*} + \sqrt{\tau_L})^2} + 3\gamma W_0 \alpha(4b + 3\phi) \right], \tag{A7}$$

which is negative for any $\phi \in [-\frac{b}{2}, 0)$. The monotonicity of $G(\tau_*; a_S, a_T, \phi, [\tau_L, \tau_*])$ dictates that there is at most one interior solution for equation (22), and we will always have a unique τ_* in equilibrium.

(*Constant Values*) Since $G(\tau_*; a_S, a_T, [\tau_L, \tau_*])$ is a continuous and decreasing function of τ_*, with Intermediate Value Theorem, a sufficient and necessary condition for $\tau_* \in (\tau_L, \tau_H)$ is

$$\begin{cases} \lim_{\tau_* \longrightarrow \tau_L} G(\tau_*; a_S, a_T, \phi, [\tau_L, \tau_*]) > 0 \\ \lim_{\tau_* \longrightarrow \tau_H} G(\tau_*; a_S, a_T, \phi, [\tau_L, \tau_*]) < 0. \end{cases}$$

This is equivalent to

$$\begin{cases} a_T - a_S - \frac{1}{2}\phi(b + \phi)\gamma W_0^2 \alpha^2 (1 - 4\tau_L) > 0 \\ a_T - a_S + \frac{1}{6}\phi W_0 \alpha \left\{ \frac{2(\tau_H + \sqrt{\tau_H \tau_L} - 2\tau_L)}{\sqrt{\tau_H} + \sqrt{\tau_L}} - 3\gamma W_0 \alpha \left[b(1 - 4\tau_H) - \phi(1 - 3\tau_H - \tau_L) \right] \right\} < 0 \end{cases}.$$

Match them to conditions in Proposition 1 yields constant term values.

Proof of Lemma 2

From equation (26), two single-manager funds are expected to deliver flow-benefits to fund family equal to

$$(B - b)W_0(\sqrt{\tilde{\tau}_i} + \sqrt{\tilde{\tau}_{-i}})\alpha + CW_0\alpha^2. \tag{A8}$$

If the same two managers work in a team-managed fund, from equation (30), expected flow-benefits are

$$(B - b)W_0(\sqrt{\tilde{\tau}_i} + \sqrt{\tilde{\tau}_{-i}})\alpha + CW_0(\frac{1}{2} + \sqrt{\tilde{\tau}_i \tilde{\tau}_{-i}})\alpha^2. \tag{A9}$$

Compare A8 and A9, we can see that linear flows are the same across different types of funds, but differ in convex terms. Since $\tilde{\tau}_i, \tilde{\tau}_{-i} \in \Phi \subset (0, \frac{1}{4})$, we have $\sqrt{\tilde{\tau}_i \tilde{\tau}_{-i}} < \frac{1}{4}$.

Proof of Proposition 2

We start from a special case where $a_T = a_S$. Suppose instead $\phi > 0$, for an arbitrary threshold skill level $\tau_* \in [\tau_L, \tau_H]$, the subset of managers who choose team-management contract is $\Gamma = [\tau_*, \tau_H]$ according to Lemma 1. Insert a_T and Γ into the utility gap function 19. For the threshold manager:

$$\begin{aligned} &G(\tau_*; a_S, a_S, \phi, [\tau_*, \tau_H]) = \phi W_0 \alpha \big[\sqrt{\tau_*} - E(\sqrt{\tilde{\tau}_{-i}} | \tilde{\tau}_{-i} \in [\tau_*, \tau_H])\big] \\ &-\frac{\gamma W_0^2 \alpha^2}{4} \Big\{ (\phi^2 + 2b\phi)(1 - 4\tau_*) + \phi^2 \big[1 - 4E(\tilde{\tau}_{-i} | \tilde{\tau}_{-i} \in [\tau_*, \tau_H])\big] \Big\}, \end{aligned} \tag{A10}$$

which is always negative for any τ_*.

A negative utility gap implies that the threshold manager has incentive to deviate and choose the single-management contract. If she deviates, then the next manager with marginally better skill faces the same problem. The arbitrariness of τ^* implies that no manager would choose the team-management contract in equilibrium. That is to say, if the fund family offers the same fixed salary to two contracts, it is equivalent to offering only team-management contract.

Then what if $a_T \neq a_S$? From Lemma 2 , we see that it is optimal for the fund family's revenue if all managers choose the single-management contract. Therefore, there is no incentive for the family to change fixed salary and induce any other equilibrium given a positive ϕ. So $\phi > 0$ makes the team-management contract trivial.

Proof of Lemma 3

For an interior case in 22, threshold manager's indifferent condition is

$$G(\tau_*; a_S, a_T, \phi, [\tau_L, \tau_*]) = 0. \tag{A11}$$

It can be simplified to

$$a_T - a_S + \frac{1}{6}\phi W_0 \alpha \left\{ \frac{2(\tau_* + \sqrt{\tau_* \tau_L} - 2\tau_L)}{\sqrt{\tau_*} + \sqrt{\tau_L}} - 3\gamma W_0 \alpha \big[b(1 - 4\tau_*) - \phi(1 - 3\tau_* - \tau_L) \big] \right\} = 0. \tag{A12}$$

If we differentiate with respect to a_S and a_T at both sides, respectively, we get

$$\frac{\partial \tau_*(a_S, a_T)}{\partial a_S} = \frac{1}{\partial G(\tau_*; a_S, a_T, \phi, [\tau_L, \tau_*]) / \partial \tau_*}, \tag{A13}$$

and

$$\frac{\partial \tau_*(a_S, a_T)}{\partial a_T} = -\frac{1}{\partial G(\tau_*; a_S, a_T, \phi, [\tau_L, \tau_*]) / \partial \tau_*}. \tag{A14}$$

Since we have

$$\frac{\partial G(\tau_*; a_S, a_T, \phi, [\tau_L, \tau_*])}{\partial \tau_*} < 0,$$

from A7, this completes the proof.

Proof of Proposition 3

We prove it by showing that, with $\phi = -\frac{b}{2}$ and smaller fixed salary $\{\tilde{a}_S, \tilde{a}_T, -\frac{b}{2}\}$, we can always construct a new equilibrium with the same threshold τ_* to an equilibrium induced by any $\bar{\phi} \in (-\frac{b}{2}, 0)$. Since only τ_* and fixed salary affect the fund family's profit, the new equilibrium dominates the original one.

To begin the proof, we show the effect of a marginal change of ϕ on equilibrium τ_*. Take first and second order derivatives of $G(\tau^*; a_S, a_T\phi, [\tau_L, \tau_*])$ with respect to ϕ :

$$\frac{\partial G(\tau_*; a_S, a_T, \phi, [\tau_L, \tau_*])}{\partial \phi} = \frac{1}{6} W_0 \alpha \left[\frac{2(\tau_* + \sqrt{\tau_* \tau_L} - 2\tau_L)}{\sqrt{\tau_*.} + \sqrt{\tau_L}} - 3\gamma b W_0 \alpha (1 - 4\tau_*) - 6\gamma \phi W_0 \alpha (1 - 3\tau_* - \tau_L) \right], \tag{A15}$$

and

$$\frac{\partial^2 G(\tau_*; a_S, a_T, \phi, [\tau_L, \tau_*])}{\partial \phi^2} = -\gamma W_0^2 \alpha^2 (1 - 3\tau_* - \tau_L). \tag{A16}$$

The sign of the first derivative is undetermined. But for the second, it is negative for any $\tau_* \in [\tau_L, \tau_H]$, which means $G(\tau_*; a_S, a_T, \phi, [\tau_L, \tau_*])$ is a strictly concave function of ϕ. As ϕ decreases, given the same τ^*, a_S, and a_T, G may increase or decrease. We analyze these two cases separately and start with an arbitray feasible set of parameters: $\{\bar{a}_S, \bar{a}_T, \bar{\phi}\}$.

1) If $G(\tau_*; \bar{a}_S, \bar{a}_T, \bar{\phi}, [\tau_L, \tau_*])$ decreases when $\bar{\phi}$ shifts to $-\frac{b}{2}$ from a larger negative value, we can easily construct a new equilibrium by reducing fixed salary for single-management contract $\bar{a}_S$ while keeping $\tilde{a}_T = \bar{a}_T$. Since G decreases linearly in a_S, such a reduction in $\bar{a}_S$ leads to an increase in G. There is no lower bound for a_S, so there must exist an $\tilde{a}_S < \bar{a}_S$ such that

$$G(\tau_*; \tilde{a}_S, \bar{a}_T, -\frac{b}{2}, [\tau_L, \tau_*]) = G(\tau_*; \bar{a}_S, \bar{a}_T, \bar{\phi}, [\tau_L, \tau_*]), \tag{A17}$$

and equilibrium τ_* is brought back to the value before we change ϕ.

2) If $G(\tau_*; \bar{a}_S, \bar{a}_T, \bar{\phi}, [\tau_L, \tau_*])$ increases when $\bar{\phi}$ shifts to $-\frac{b}{2}$ from a larger negative value, we can similarly reduce $\bar{a}_T$ while keeping $\tilde{a}_S = \bar{a}_S$ to replicate the old equilibrium. However, given managers' participation constraint, there exists an effective lower bound for a_T. Define function $\hat{a}_T(\phi)$ as the optimal (smallest) choice of a_T for the fund family as a function of parameter ϕ. According to Lemma 4, it is

$$\hat{a}_T(\phi) = \underline{\mathrm{U}} + \frac{1}{4}\gamma \left[(b + \phi)^2 + \phi^2 \right] W_0^2 \alpha^2 (1 - 4\tau_L) - b W_0 \alpha \sqrt{\tau_L}. \tag{A18}$$

Note that this lower bound will be smaller as ϕ decreases. Replace $\bar{a_T}$ and $\bar{\phi}$ with $\hat{a}_T(\phi)$ and ϕ, we get $G(\tau_*; \bar{a}_S, \hat{a}_T(\phi), \phi, [\tau_L, \tau_*])$. Differentiate it with respect to ϕ,

$$\frac{\partial G(\tau_*; \bar{a}_S, \hat{a}_T(\phi), \phi, [\tau_L, \tau_*])}{\partial \phi} = \frac{1}{3} W_0 \alpha \left[\frac{\tau_* + \sqrt{\tau_* \tau_L} - 2\tau_L}{\sqrt{\tau_*} + \sqrt{\tau_L}} + 3\gamma(2b + 3\phi) W_0 \alpha (\tau_* - \tau_L) \right], \quad \text{(A19)}$$

which is positive. It implies that when optimal fixed salary for team managers is imposed, utility gap monotonically increases in ϕ for any τ_*. Then we have

$$G(\tau_*; \bar{a}_S, \hat{a}_T\big(-\frac{b}{2}\big), -\frac{b}{2}, [\tau_L, \tau_*]) < G(\tau_*; \bar{a}_S, \hat{a}_T(\bar{\phi}), \bar{\phi}, [\tau_L, \tau_*])$$

$$\leqslant G(\tau_*; \bar{a}_S, \bar{a}_T, \bar{\phi}, [\tau_L, \tau_*])$$

for $\forall \tau_* \in [\tau_L, \tau_H]$. So there must exists an $\tilde{a}_T \in \big(\hat{a}_T(-\frac{b}{2}), \bar{a}_T\big)$, such that

$$G(\tau_*; \bar{a}_S, \tilde{a}_T, -\frac{b}{2}, [\tau_L, \tau_*]) = G(\tau_*; \bar{a}_S, \bar{a}_T, \bar{\phi}, [\tau_L, \tau_*]). \quad \text{(A20)}$$

This completes the proof.

Proof of Proposition 4

Integrate over equilibrium $\Gamma = [\tau_L, \tau_*]$ and $\Gamma^c = [\tau_*, \tau_H]$ for single and team managers, expected profits per manager are:

$$E\left[\tilde{\pi}_{i,S}(a_S)\right] = \int_{\tau_*(a_S)}^{\tau_H} \frac{E\left[\tilde{\pi}_S(a_S); \tilde{\tau}_i)\right]}{\tau_H - \tau_*(a_S)} d\tilde{\tau}_i, \quad \text{(A21)}$$

which is

$$E\left[\tilde{\pi}_{i,S}(a_S)\right] = AW_0 - a_S + \frac{2}{3}(B - b) W_0 \alpha \frac{\tau_H^{\frac{3}{2}} - \tau_*^{\frac{3}{2}}}{\tau_H - \tau_*} + \frac{1}{2} C W_0 \alpha^2. \quad \text{(A22)}$$

and

$$E\left[\tilde{\pi}_{i,T}(a_S)\right] = \int_{\tau_L}^{\tau_*(a_S)} \int_{\tau_L}^{\tau_*(a_S)} \frac{E\left[\tilde{\pi}_T(a_S; \tilde{\tau}_i, \tilde{\tau}_{-i})\right]}{\left(\tau_*(a_S) - \tau_L\right)^2} d\tilde{\tau}_i d\tilde{\tau}_{-i}, \quad \text{(A23)}$$

which is

$$E\left[\tilde{\pi}_{i,T}(a_S)\right] = AW_0 - a_T + \frac{2}{3}(B - b) W_0 \alpha \frac{\tau_*^{\frac{3}{2}} - \tau_L^{\frac{3}{2}}}{\tau_* - \tau_L} + \frac{1}{4} C W_0 \alpha^2 + \frac{2}{9} C W_0 \alpha^2 \left(\frac{\tau_*^{\frac{3}{2}} - \tau_L^{\frac{3}{2}}}{\tau_* - \tau_L} \right)^2. \quad \text{(A24)}$$

Insert A22 and A24 into the objective function of the fund family's expected profit maximization problem 33 and collect terms, we have

$$\Pi = AW_0 + \frac{1}{4}CW_0\alpha^2 + \frac{2}{3}(B-b)W_0\alpha\frac{\tau_H^{\frac{3}{2}} - \tau_L^{\frac{3}{2}}}{\tau_H - \tau_L} - \frac{(\tau_H - \tau_*)a_S + (\tau_* - \tau_L)a_T}{\tau_H - \tau_L} + \frac{CW_0\alpha^2}{\tau_H - \tau_L}\left[\frac{\tau_H - \tau_*}{4} + \frac{2}{9}\frac{\left(\tau_*^{\frac{3}{2}} - \tau_L^{\frac{3}{2}}\right)^2}{\tau_* - \tau_L}\right]. \tag{A25}$$

For convenience, we define terms related to fixed salary a_S as functions of τ_*:

$$K(\tau_*) = \frac{(\tau_H - \tau_*)a_S(\tau_*) + (\tau_* - \tau_L)a_T}{\tau_H - \tau_L}, \tag{A26}$$

and

$$L(\tau_*) = \frac{\tau_H - \tau_*}{4} + \frac{2}{9}\frac{\left(\tau_*^{\frac{3}{2}} - \tau_L^{\frac{3}{2}}\right)^2}{\tau_* - \tau_L}. \tag{A27}$$

Then the objective function can be written as

$$\Pi = AW_0 + \frac{1}{4}CW_0\alpha^2 + \frac{2}{3}(B-b)W_0\alpha\frac{\tau_H^{\frac{3}{2}} - \tau_L^{\frac{3}{2}}}{\tau_H - \tau_L} - K(\tau_*) + \frac{CW_0\alpha^2}{\tau_H - \tau_L}L(\tau_*). \tag{A28}$$

1) When $C = 0$, maximization problem 33 is equivalent to

$$\underset{\tau_* \in [\tau_H, \tau_L]}{Min} \; K(\tau_*).$$

Twice differentiate $K(\tau_*)$ with respect to τ_*:

$$K''(\tau_*) = \frac{(\tau_H - \tau_*)a_S''(\tau_*) - 2a_S'(\tau_*)}{\tau_H - \tau_L}. \tag{A29}$$

We have

$$a_S'(\tau_*) = \frac{1}{\partial\tau_*(a_S)/\partial a_S} < 0 \tag{A30}$$

from the proof of Lemma 3 . To find out $a_S''(\tau_*)$, twice differentiate with respect to τ_* at both sides of equation (A12):

$$a_S''(\tau_*) = -\phi W_0\alpha\frac{\tau_*^{\frac{3}{2}} + 3\tau_*\sqrt{\tau_L} + 9\sqrt{\tau_*}\tau_L + 3\tau_L^{\frac{3}{2}}}{12(\sqrt{\tau_*} + \sqrt{\tau_L})^3} > 0. \tag{A31}$$

Then we have

$$K''(\tau_*) > 0,$$

which means that $K(\tau_*)$ is a strictly convex function of τ_*. So the optimal choice of τ_* solves the first order condition:

$$K'(\tau_*) = a_T - a_S(\tau_*) + (\tau_H - \tau_*)a'_S(\tau_*) = 0. \tag{A32}$$

Since $c_2 > 0$, $a_S(\tau_L) > a_T$. Then if we insert $\tau_* = \tau_L$ into $K'(\tau_*)$, we have

$$K'(\tau_L) = a_T - a_S(\tau_L) + (\tau_H - \tau_L)a'_S(\tau_L) < 0. \tag{A33}$$

In addition, if $c_1 < 0$, then

$$K'(\tau_H) = a_T - a_S(\tau_H) > 0. \tag{A34}$$

With (A33) and (A34), the optimal choice of τ_* must satisfy $\tau_* \in (\tau_L, \tau_H)$.

2) When $C > 0$, twice differentiate Π with respect to τ_*, we have

$$\frac{\partial^2 \Pi}{\partial \tau_*^2} = \frac{CW_0\alpha^2}{\tau_H - \tau_L} L''(\tau_*) - K''(\tau_*), \tag{A35}$$

Insert full expressions of $L''(\tau_*)$, $K''(\tau_*)$ and $\phi = -\frac{b}{2}$ into it, and with some tedious calculations, we get

$$L''(\tau_*) = -\frac{W_0 r}{72(\tau_H - \tau_L)(\sqrt{\tau_L} + \sqrt{\tau_*})^3 \tau_*^{\frac{3}{2}}} \Upsilon, \tag{A36}$$

where

$$\begin{aligned} \Upsilon = {} & 90\gamma b^2 W_0 \alpha(\sqrt{\tau_L} + \sqrt{\tau_*})^3 \tau_*^{\frac{3}{2}} - 8C\alpha\tau_*(3\tau_L^2 + 5\tau_L^{\frac{3}{2}}\sqrt{\tau_*} + 12\tau_L\tau_* + 12\sqrt{\tau_L}\tau_*^{\frac{3}{2}} + 4\tau_*^{\frac{3}{2}}) \\ & + 3b\left[\tau_H(3\tau_L^{\frac{3}{2}} + 9\tau_L\sqrt{\tau_*} + 3\sqrt{\tau_L}\tau_* + \tau_*^{\frac{3}{2}}) + \tau_*(9\tau_L^{\frac{3}{2}} + 11\tau_L\sqrt{\tau_*} + 9\sqrt{\tau_L}\tau_* + 3\tau_*^{\frac{3}{2}})\right]. \end{aligned} \tag{A37}$$

Since $\tau_* \leqslant \tau_H < \frac{1}{4}$, we can shrink (A37) by multiplying the second term with $\frac{1}{2\sqrt{\tau_*}}$, and simultaneously replacing τ_H in the third term with τ_*:

$$\begin{aligned} \Upsilon > {} & 90\gamma b^2 W_0 \alpha(\sqrt{\tau_L} + \sqrt{\tau_*})^3 \tau_*^{\frac{3}{2}} - 4C\alpha\tau_*(\frac{3\tau_L^2}{\sqrt{\tau_*}} + 5\tau_L^{\frac{3}{2}} + 12\tau_L\sqrt{\tau_*} + 12\sqrt{\tau_L}\tau_* + 4\tau_*^{\frac{3}{2}}) \\ & + 3b\tau_*\left(12\tau_L^{\frac{3}{2}} + 20\tau_L\sqrt{\tau_*} + 12\sqrt{\tau_L}\tau_* + 4\tau_*^{\frac{3}{2}}\right) \end{aligned} \tag{A38}$$

When

$$C < \frac{3b}{4\alpha},$$

with the transitive property of inequalities, we can readily have

$$\frac{\partial^2\Pi}{\partial\tau_*^2} < -\frac{bW_0\alpha}{24(\tau_H-\tau_L)(\sqrt{\tau_L}+\sqrt{\tau_*})^3\tau_*}\cdot\left[30\gamma bW_0\alpha(\sqrt{\tau_L}+\sqrt{\tau_*})^3\tau_* + \left(7\tau_L^{\frac{3}{2}}\sqrt{\tau_*}+\tau_L(20\tau_*-3\tau_L)\right)\right] < 0, \tag{A39}$$

which means Π is a concave function for any $\tau^* \in [\tau_L, \tau_H]$. Thus, optimal choice of τ^* can be characterized by the first order condition:

$$\frac{\partial\Pi}{\partial\tau_*} = 0, \tag{A40}$$

which is

$$\frac{CW_0\alpha^2}{\tau_H-\tau_L}L'(\tau_*) = K'(\tau_*). \tag{A41}$$

Notice that

$$L'(\tau_*) = -\frac{1}{36}\left[9-16\tau_*-\frac{8\tau_L(\tau_L-\sqrt{\tau_L\tau_*}-\tau_*)}{(\sqrt{\tau_L}+\sqrt{\tau_*})^2}\right]. \tag{A42}$$

We can enlarge it by replacing one τ_* and one τ_L with $\frac{1}{4}$,

$$\begin{aligned} L'(\tau_*) &< -\frac{1}{36}\left[5-\frac{2(\tau_L-\sqrt{\tau_L\tau_*}-\tau^*)}{(\sqrt{\tau_L}+\sqrt{\tau_*})^2}\right] \\ &= -\frac{1}{36(\sqrt{\tau_L}+\sqrt{\tau_*})^2}\left(3\tau_L+3\tau_*+8\sqrt{\tau_L\tau_*}\right) < 0. \end{aligned} \tag{A43}$$

Then given a τ_*, a marginal increase in C causes Left Hand Side to be smaller. To ensure that the first order condition holds, a smaller τ_* is needed. The result follows as all functions are continuous and differentiable.

Proof of Lemma 5

Given signal precision τ_i, expected excess return of manager i's (sub)portfolio is

$$E(\tilde{R}_i|\tau_i) = \sqrt{\tau_i}\alpha. \tag{A44}$$

By law of total variance, unconditional variance of the portfolio is

$$Var(\tilde{R}_i|\tau_i) = E[Var(\tilde{R}_i|\tilde{s}_i)] + Var[E(\tilde{R}_i|\tilde{s}_i)], \tag{A45}$$

where

$$Var(\tilde{R}_i|\tilde{s}_i) = \begin{cases} (1-4\tau_i)\alpha^2, \text{ if } s_i = +1 \\ 0, \text{ if } s_i = -1 \end{cases},$$

and

$$E(\tilde{R}_i|\tilde{s}_i) = \begin{cases} 2\sqrt{\tau_i}\alpha, \text{ if } s_i = +1 \\ 0, \text{ if } s_i = -1 \end{cases} .$$

So

$$E[Var(\tilde{R}_i|\tilde{s}_i)] = \frac{1}{2}(1 - 4\tau_i)\alpha^2, \tag{A46}$$

and

$$Var[E(\tilde{R}_i|\tilde{s}_i)] = \tau_i\alpha^2. \tag{A47}$$

Then

$$Var(\tilde{R}_i|\tau_i) = \frac{1}{2}(1 - 2\tau_i)\alpha^2. \tag{A48}$$

Given τ_i, Information Ratio of the manager i's portfolio is

$$IR_i = \frac{E(\tilde{R}_i|\tau_i)}{\sqrt{Var(\tilde{R}_i|\tau_i)}}, \tag{A49}$$

which can be reduced to equation (5). Note that excess return volatility α are canceled out.

Proof of Lemma 6

By law of iterated expectations, team-managed fund j's unconditional expected return is

$$E(\tilde{R}_j^T|\tau_i, \tau_{-i}) = E\big[E(\tilde{R}_j^T\big|\tilde{s}_i, \tilde{s}_{-i})\big]. \tag{A50}$$

Insert (4) and (5) into (6), and average over realizations of signals, we have

$$E(\tilde{R}_j^T|\tau_i, \tau_{-i}) = \frac{1}{2}(\sqrt{\tau_i} + \sqrt{\tau_{-i}})\alpha. \tag{A51}$$

By law of total variance, unconditional variance given signal precision levels is

$$Var(\tilde{R}_j^T|\tau_i, \tau_{-i}) = E[Var(\tilde{R}_j^T|\tilde{s}_i, \tilde{s}_{-i})] + Var[E(\tilde{R}_j^T|\tilde{s}_i, \tilde{s}_{-i})] \tag{A52}$$

$$= \frac{1}{4}[(1 - \tau_i - \tau_{-i})]\alpha^2. \tag{A53}$$

Then given managers, Information Ratio of such a team-managed fund is

$$\begin{aligned} IR_j^T &= \frac{E(\tilde{R}_j^T|\tau_i, \tau_{-i})}{\sqrt{Var(\tilde{R}_j^T|\tau_i, \tau_{-i})}} \\ &= \frac{\sqrt{\tau_i} + \sqrt{\tau_{-i}}}{\sqrt{1 - \tau_i - \tau_{-i}}}. \end{aligned} \tag{A54}$$

If $\tau_{-i} = \tau_i$,

$$IR_j^T = \frac{2\sqrt{\tau_i}}{\sqrt{1-2\tau_i}}, \tag{A55}$$

which is $\sqrt{2}$ times of IR_j^S:

$$IR_j^S = IR_i. \tag{A56}$$

Proof of Proposition 5

Differentiate expected excess returns in (40) and (41) with respect to τ_*, we have

$$\frac{\partial E(\tilde{R}_j^S)}{\partial \tau_*} = \frac{\alpha(2\sqrt{\tau_H}+\sqrt{\tau_*})}{3(\sqrt{\tau_H}+\sqrt{\tau_*})^2}, \tag{A57}$$

and

$$\frac{\partial E(\tilde{R}_j^T)}{\partial \tau_*} = \frac{\alpha(2\sqrt{\tau_L}+\sqrt{\tau_*})}{3(\sqrt{\tau_L}+\sqrt{\tau_*})^2}, \tag{A58}$$

both of which are always positive. It implies average excess return increases in τ_* for both types of funds.

Ex ante variances for single-manager and team-managed funds can be calculated with law of total variances:

$$Var(\tilde{R}_j^S) = E[Var(\tilde{R}_j^S|\tilde{\tau}_i)|\tilde{\tau}_i \in [\tau_*, \tau_H]] + Var[E(\tilde{R}_j^S|\tilde{\tau}_i)|\tilde{\tau}_i \in [\tau_*, \tau_H]], \tag{A59}$$

and

$$Var(\tilde{R}_j^T) = E\big[Var(R_j^T|\tilde{\tau}_i, \tilde{\tau}_{-i})|\tilde{\tau}_i, \tilde{\tau}_{-i} \in [\tau_L, \tau_*]\big] + Var\big[E(R_j^T|\tilde{\tau}_i, \tilde{\tau}_{-i})|\tilde{\tau}_i, \tilde{\tau}_{-i} \in [\tau_L, \tau_*]\big]. \tag{A60}$$

Insert (A44), (A48) into (A59), and (A50), (A51) into (A60), and calculate first and second order moments conditional on corresponding subsets of managers, we have

$$Var(\tilde{R}_j^S) = \Big[\frac{1}{2} - \frac{4}{9}(\frac{\tau_H^{\frac{3}{2}} - \tau_*^{\frac{3}{2}}}{\tau_H - \tau_*})^2\Big]\alpha^2, \tag{A61}$$

and

$$Var(\tilde{R}_j^T) = \Big[\frac{1}{4} - \frac{2}{9}(\frac{\tau_*^{\frac{3}{2}} - \tau_L^{\frac{3}{2}}}{\tau_* - \tau_L})^2\Big]\alpha^2. \tag{A62}$$

Both of the two variances decrease in τ_* :

$$\frac{\partial Var(\tilde{R}_j^S)}{\partial \tau_*} = -\frac{4}{9}\Big[1 + \frac{\tau_H^{\frac{3}{2}}}{(\sqrt{\tau_H}+\sqrt{\tau_*})^3}\Big]\alpha^2, \tag{A63}$$

and

$$\frac{\partial Var(\tilde{R}_j^T)}{\partial \tau_*} = -\frac{2}{9}\Big[1 + \frac{\tau_L^{\frac{3}{2}}}{(\sqrt{\tau_L} + \sqrt{\tau_*})^3}\Big]\alpha^2. \tag{A64}$$

Expected Information Ratio of single-manager fund j solely managed by manager i is

$$E\left[IR_j^S\left(\tilde{\tau}_i\right)\right] = \int_{\tau_*}^{\tau_H} \frac{IR_j^S(\tilde{\tau}_i)}{\tau_H - \tau_*} d\tilde{\tau}_i. \tag{A65}$$

Differentiate $E\left[IR_j^S\left(\tilde{\tau}_i\right)\right]$ with respect to τ_*,

$$\begin{aligned} \frac{dE\left[IR_j^S\left(\tilde{\tau}_i\right)\right]}{d\tau_*} &= \int_{\tau_*}^{\tau_H} \frac{IR_j^S(\tilde{\tau}_i)}{\left(\tau_H - \tau_*\right)^2} d\tilde{\tau}_i - \frac{IR_j^S(\tau_*)}{\tau_H - \tau_*} \\ &= \frac{E\left[IR_j^S\left(\tilde{\tau}_i\right)\right] - IR_j^S(\tau_*)}{\tau_H - \tau_*}. \end{aligned} \tag{A66}$$

In Lemma 5, we have shown manager level Information Ratio increases in signal precision. So for any $\tau_* < \tau_H$, (A66) is positive.

Expected Information Ratio of a team-managed fund is

$$E\left[IR_j^T(\tilde{\tau}_i, \tilde{\tau}_{-i})\right] = \int_{\tau_L}^{\tau_*} \int_{\tau_L}^{\tau_*} \frac{IR_j^T(\tilde{\tau}_i, \tilde{\tau}_{-i})}{\left(\tau_* - \tau_L\right)^2} d\tilde{\tau}_i d\tilde{\tau}_{-i}. \tag{A67}$$

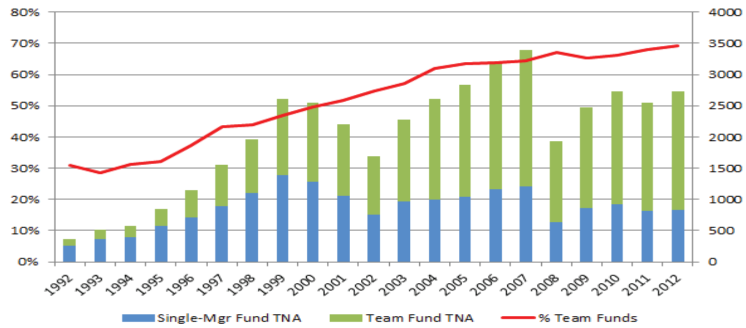
Differentiate it with respect to τ_* gives

$$\begin{aligned} \frac{dE\left[IR_j^T(\tilde{\tau}_i, \tilde{\tau}_{-i})\right]}{d\tau_*} &= \int_{\tau_L}^{\tau_*} \frac{IR_j^T(\tilde{\tau}_i, \tau_*)}{\left(\tau_* - \tau_L\right)^2} d\tilde{\tau}_i + \int_{\tau_L}^{\tau_*} \frac{IR_j^T(\tau_*, \tilde{\tau}_{-i})}{\left(\tau_* - \tau_L\right)^2} d\tilde{\tau}_{-i} - 2\int_{\tau_L}^{\tau_*} \int_{\tau_*}^{\tau_H} \frac{IR_j^T(\tau_i, \tau_{-i})}{\left(\tau_* - \tau_L\right)^3} d\tilde{\tau}_i d\tilde{\tau}_{-i} \\ &= \frac{E\left[IR_j^T(\tilde{\tau}_i, \tau_*)\right] + E\left[IR_j^T(\tau_*, \tilde{\tau}_{-i})\right] - 2E\left[IR_j^T(\tilde{\tau}_i, \tilde{\tau}_{-i})\right]}{\tau_* - \tau_L}. \end{aligned} \tag{A68}$$

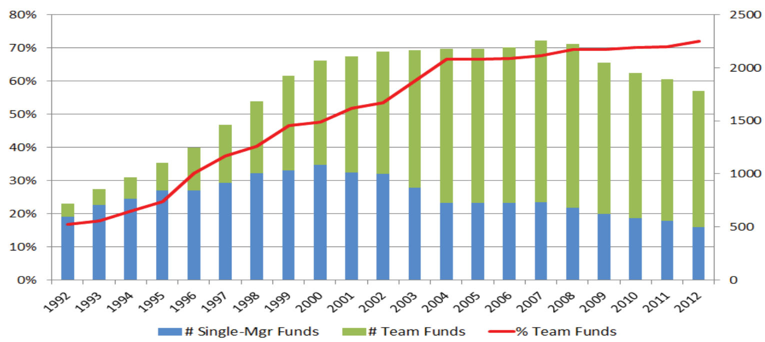
From equation (A52) in proof of Lemma 6, a team-managed fund's Information Ratio increases in signal precision of both managers. Then for any $\tau_* > \tau_L$, (A68) is positive.

B Appendix: Figures and Tables

(a) Total Net Assets



(b) Number of Funds



(c) Performance Difference

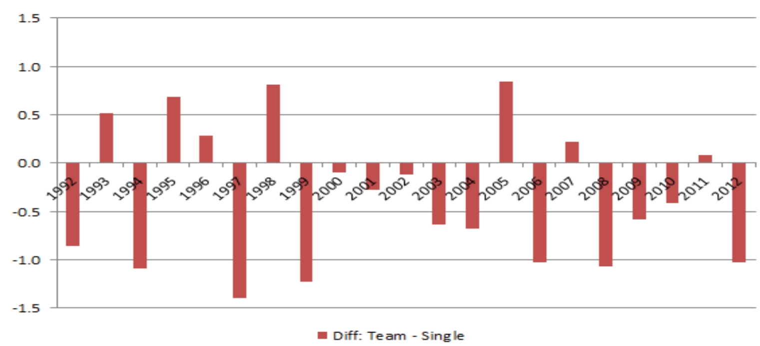
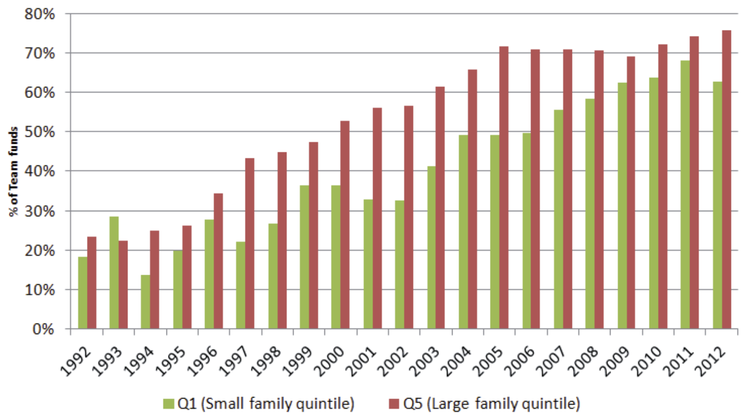


Figure 1: The growth and performance of team funds. Panel (a) reports the Total Net Assets (TNA) for single-manager and team funds. The red line reports the fraction of total TNA managed by team funds. Panel (b) reports the number of funds. Panel (c) is the performance difference between team and single-manager funds. The sample is actively managed U.S. domestic equity funds from CRSP Survivorship Bias Free Mutual Fund Database, from 1992 to 2012.

(a) Total Net Assets



(b) Number of Funds

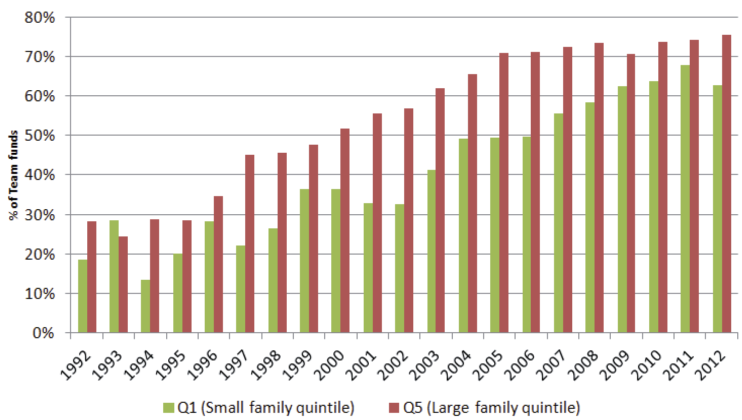
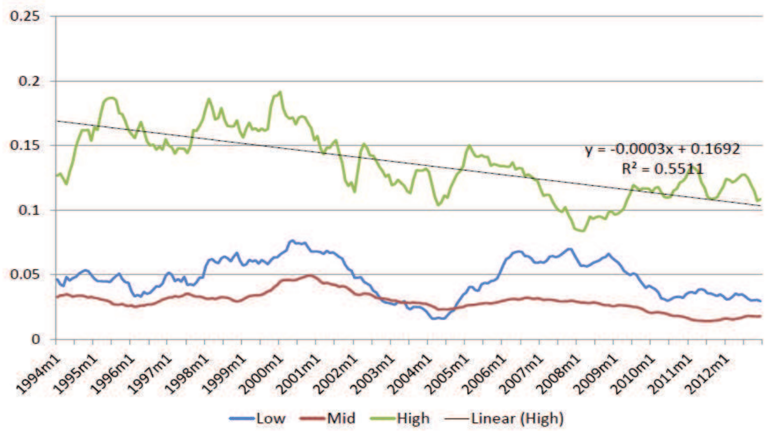


Figure 2: Fraction of team funds for small vs. large families. This figure plots the yearly averages of the percentage of team funds in the smallest and largest family size quintiles (Q1 and Q5) over the sample period from 1992 to 2012. The percentage of team funds is calculated using funds' total net assets in Panel (a) and the number of funds in Panel (b).

(a) Regression Coefficient based on Net Returns



(b) Regression Coefficient based on Four-Factor Alpha

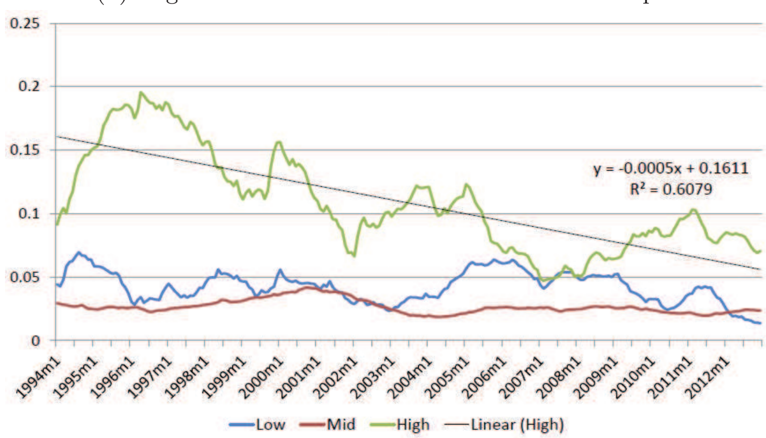


Figure 3: Time series trend in flow-performance convexity. Panels (a) and (b) plot the 2-year moving averages of the monthly coefficient estimates of the Low, Mid, and High groups based the results in columns (1) and (3) of Table 2, respectively.

Table 1: **Summary Statistics**

This table summarizes the characteristics of the mutual funds in our sample over the period between 1992 and 2012. There are 3288 unique actively managed U.S. equity funds. Four-Factor Alpha is estimated using monthly fund net returns with Carhart (1997) four-factor model. We first estimate the factor loadings using the preceding 24 monthly returns. We then calculate monthly out-of-sample alpha as the difference between a funds return in a given month and the sum of the product of the estimated factor loadings and the factor returns during that month. Active share is calculated by aggregating the absolute differences between the weight of a portfolios actual holdings and the weight of its closest matching index. Return gap measures the difference between fund gross returns and holdings-based returns. Industry concentration index is calculated as the sum of the squared deviations of the value weights for each industry held by the mutual fund, relative to the industry weights of the total stock market. Team fund is an indicator variable that equals to one if the fund is managed by a team of portfolio managers based on CRSP mutual fund data and zero otherwise. Fund TNA is the sum of assets under management across all share classes of the fund; Fund Age is the age of the oldest share class in the fund; Expense Ratio is computed by dividing the funds annual operating expenses by the average dollar value of its assets under management; Net Flows is constructed as the net growth in fund assets beyond reinvested dividends (Sirri and Tufano, 1998); Turnover Ratio is defined as the minimum of sales or purchases divided by the total net assets of the fund; Family Size is the sum of total net assets of all equity funds in a fund family.

Variables	Mean	Median	Std. Dev.	p1	p99	N
Net Return (in % per year)	7.94	13.20	67.07	-193.04	168.65	422,453
Four-Factor Alpha (in % per year)	-1.03	-1.06	26.67	-87.34	87.96	415,167
Active Share	0.83	0.88	0.16	0.32	1.00	392,216
Return Gap (in % per year)	-0.13	-0.13	15.65	-45.62	45.09	359,008
Industry Concentration Index	0.10	0.04	0.16	0.00	0.79	357,989
Team Fund	0.546	1.000	0.498	0.000	1.000	422,831
Fund TNA (in Millions)	1,175.8	231.4	4,479.6	16.4	16,946.4	422,831
Fund Age (in Months)	160.0	114.0	157.3	10.0	818.0	422,811
Expense Ratio (%)	1.266	1.230	0.451	0.100	2.540	414,456
Fund Flow (%)	0.590	-0.228	5.295	-14.249	28.930	422,721
Turnover Ratio	0.850	0.650	0.744	0.020	4.200	416,302
Family TNA (in Millions)	35,522	5,473	90,883	20	477,679	422,831
Family Fund Numbers	17.1	10.0	22.9	1.0	114.0	422,831

Table 2: **Family Size and the Flow-Performance Relationship**
This table reports Fama-MacBeth piecewise linear regression results of monthly fund flows on lagged funds fractional performance rankings. Each month, funds are assigned fractional performance ranks from zero to one based on their past 12-month net returns relative to other funds with similar investment objectives (columns (1) and (2)), or based on their four-factor alphas during the past 24 months (columns (3) and (4)). The fractional rank for funds in the bottom performance quintile (Low) is defined as Min (Rank, 0.2). Funds in the three medium performance quintiles (Mid) are grouped together and receive ranks that are defined as Min (0.6, Rank - Low). The rank for the top performance quintile (High) is defined as Rank - Mid - Low. Large family is an indicator variable that equals one if the fund belongs to a family whose size is above median value and zero otherwise. Category flow measures the aggregate monthly flow into each fund objective category. All other variables are defined in Table 1. Standard errors are adjusted using the Newey and West (1987) correction with 12 lags and t-statistics are reported in parentheses. The superscripts ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Past 12m Net Return		Four-Factor Alpha	
VARIABLES	(1)	(2)	(3)	(4)
Low	0.046***	0.053***	0.040***	0.046***
	(10.55)	(10.33)	(8.42)	(7.78)
Mid	0.029***	0.028***	0.027***	0.025***
	(14.33)	(13.66)	(19.83)	(15.14)
High	0.134***	0.147***	0.105***	0.132***
	(17.22)	(16.44)	(10.23)	(10.49)
Low * Large Family		-0.016***		-0.012*
		(-2.79)		(-1.73)
Mid * Large Family		0.002		0.003**
		(1.53)		(2.17)
High * Large Family		-0.024**		-0.050***
		(-2.40)		(-4.37)
Category Flow	0.302***	0.303***	0.269***	0.274***
	(5.94)	(5.95)	(5.14)	(5.17)
Log Family Size	0.000		0.000	
	(1.31)		(1.42)	
Large Family		0.004***		0.004***
		(3.22)		(3.24)
Team Fund	0.001	0.001	0.001	0.001
	(0.79)	(0.87)	(1.00)	(0.97)
Log Fund TNA	0.000	0.000	0.000	0.000
	(1.54)	(1.13)	(0.46)	(0.14)
Log Fund Age	-0.007***	-0.007***	-0.007***	-0.007***
	(-14.87)	(-14.90)	(-14.92)	(-14.98)
Expense Ratio	0.000	0.000	0.000	0.000
	(0.43)	(0.48)	(0.25)	(0.29)
Turnover Ratio	-0.000	-0.000	0.000	0.000
	(-0.89)	(-0.92)	(0.67)	(0.71)
Volatility	-0.141***	-0.140***	-0.103***	-0.101***
	(-3.38)	(-3.30)	(-3.04)	(-2.90)
Constant	0.018***	0.018***	0.018***	0.018***
	(5.04)	(4.97)	(5.13)	(5.28)
Observations	403,665	403,665	402,540	402,540
R-squared	0.115	0.118	0.101	0.105
Number of months	252	252	252	252

Table 3: **Fractions of Team Funds across Family Size Quintiles**
This table reports the portfolio sorting results of percentage of team funds across different family size quintiles. Each month, we sort fund families into quintiles each month based on lagged family size and calculate the time series average of the percentage of team funds for each of the family size quintiles. We calculate for each fund family the percentage of team funds based on the number of funds or fund TNA. We test the difference in team fund percentage between the smallest and largest family size quintiles and adjust standard errors using the Newey-West (1987) correction with 12 lags.

Family Size Quintile	No. of Months	Family TNA	% of Team Funds - No. of Funds	% of Team Funds - Fund TNA
Q1 (small family)	252	33.8	40.7%	40.7%
Q2	252	121.2	44.8%	44.2%
Q3	252	407.1	51.9%	52.3%
Q4	252	1,722.3	53.5%	53.7%
Q5 (large family)	252	23,360.1	54.0%	55.1%
Diff: Q5-Q1			**13.3%**	**14.3%**
t-stat.			**9.98**	**8.25**

Table 4: **Performance of Team vs. Single-Manager Funds - Within Family**
This table reports Fama-MacBeth regression results of fund performance on a team fund dummy and other control variables with family fixed effects. We measure fund performance using net return in columns (1) and (2) and four-factor alpha in columns (3) and (4). Team Fund is an indicator variable that equals to one if the fund is managed by a team of portfolio managers based on CRSP mutual fund data and zero otherwise. All other variables are defined in Table 1. Standard errors are computed using the time series of monthly estimates as in Fama-MacBeth (1973) and t-statistics are reported in parentheses. The superscripts ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Net Return		Four-Factor Alpha	
VARIABLES	(1)	(2)	(3)	(4)
Team Fund	-0.350*	-0.332**	-0.279*	-0.301**
	(-1.73)	(-2.03)	(-1.85)	(-2.09)
Middle Family		2.889		-0.992
		(1.13)		(-0.46)
Large Family		1.993		2.120
		(0.96)		(1.13)
Log Fund TNA		-0.482***		-0.330***
		(-3.20)		(-3.61)
Log Fund Age		0.362**		0.073
		(2.31)		(0.63)
Expense Ratio		-0.032		-0.426
		(-0.05)		(-1.12)
Fund Flow		0.089***		0.067***
		(3.05)		(3.52)
Turnover Ratio		0.213		0.049
		(0.51)		(0.20)
Lagged Fund Return		0.084***		0.011
		(4.07)		(0.89)
Constant	6.168*	7.366**	-5.062***	0.581
	(1.71)	(2.10)	(-2.65)	(0.22)
Family Fixed Effects	Yes	Yes	Yes	Yes
Observations	420,019	407,357	412,765	405,363
R-squared	0.307	0.411	0.306	0.356
Number of Months	252	252	252	252

Table 5: **Portfolio Management Activeness of Team vs. Single-Manager Funds - Within Family**.
This table reports Fama-MacBeth regression results of fund portfolio management activeness measures on a team fund dummy and other control variables with family fixed effects. We measure fund portfolio management activeness using Active Share in columns (1) and (2), Return Gap in columns (3) and (4), and Industry Concentration in columns (5) and (6). Team Fund is an indicator variable that equals to one if the fund is managed by a team of portfolio managers based on CRSP mutual fund data and zero otherwise. All other variables are defined in Table 1. Standard errors are computed using the time series of monthly estimates as in Fama-MacBeth (1973) and t-statistics are reported in parentheses. The superscripts ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Active Share		Return Gap		Industry Concentration	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Team Fund	-0.008***	-0.003***	-0.085	-0.162	-0.017***	-0.011***
	(-10.51)	(-3.56)	(-0.95)	(-0.68)	(-17.23)	(-10.98)
Middle Family		0.040***		1.148		0.027***
		(4.18)		(0.47)		(2.89)
Large Family		0.058***		2.166		0.047***
		(6.99)		(0.98)		(5.68)
Log Fund TNA		-0.009***		-0.299***		-0.017***
		(-14.06)		(-4.49)		(-59.55)
Log Fund Age		0.000		-0.055		0.020***
		(0.26)		(-0.59)		(12.27)
Expense Ratio		0.126***		-0.163		0.074***
		(40.97)		(-0.31)		(46.24)
Fund Flow		0.000**		-0.010		-0.000
		(2.09)		(-0.31)		(-0.58)
Turnover Ratio		0.017***		-0.135		-0.012***
		(21.82)		(-0.76)		(-12.09)
Lagged Fund Return		0.000***		0.036***		0.000***
		(3.43)		(7.46)		(2.95)
Constant	0.844***	0.669***	-1.054	-6.427**	0.091***	0.011
	(90.83)	(54.46)	(-1.02)	(-2.05)	(14.18)	(0.91)
Family Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	392,216	381,179	359,008	348,869	357,989	348,121
R-squared	0.326	0.457	0.348	0.381	0.301	0.359
Number of Months	252	252	249	249	247	247

Table 6: **Information Ratio of Team vs. Single-Manager Funds - Within Family**.
This table reports Fama-MacBeth regression results of information ratio on a team fund dummy and other control variables with family fixed effects. Each year we calculate the average of monthly four-factor alphas, volatility (i.e., standard deviation) of alpha, and information ratio (i.e., alpha mean over its standard deviation). We use average alpha as the dependent variable in columns (1) and (2), volatility of alpha in columns (3) and (4), and information ratio in columns (5) and (6). Team Fund is an indicator variable that equals to one if the fund is managed by a team of portfolio managers based on CRSP mutual fund data and zero otherwise. All other variables are defined in Table 1. Standard errors are computed using the time series of yearly estimates as in Fama-MacBeth (1973) and t-statistics are reported in parentheses. The superscripts ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Four-Factor Alpha Mean		Four-Factor Alpha STD		Information Ratio	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Team Fund	-0.338**	-0.304*	-0.425***	-0.265***	-0.065**	-0.053**
	(-2.19)	(-2.03)	(-4.60)	(-3.11)	(-2.73)	(-2.21)
Middle Family		-0.522		1.300		-0.020
		(-0.56)		(1.29)		(-0.12)
Large Family		-1.256		0.836		-0.012
		(-1.25)		(0.88)		(-0.08)
Log Fund TNA		-0.350***		-0.261***		-0.045***
		(-3.30)		(-4.70)		(-2.93)
Log Fund Age		0.171		0.161		0.014
		(1.30)		(1.68)		(0.97)
Expense Ratio		-0.373		2.688***		0.038
		(-0.83)		(13.86)		(0.77)
Fund Flow		0.020		-0.021**		0.003
		(1.03)		(-2.19)		(1.23)
Turnover Ratio		0.272		0.413***		0.028
		(0.96)		(5.59)		(0.92)
Lagged Fund Return		-0.016		0.007		-0.001
		(-1.51)		(1.35)		(-0.69)
Constant	-3.845*	-1.098	7.076***	4.987**	-0.449	-0.278
	(-1.83)	(-0.38)	(5.60)	(2.70)	(-1.66)	(-1.03)
Family Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	35,904	34,658	35,897	34,653	35,897	34,653
R-squared	0.318	0.355	0.340	0.447	0.315	0.349
Number of Years	21	21	21	21	21	21

Table 7: **Fund Performance across Families**

This table reports Fama-MacBeth regression results of fund four-factor alpha on two family size dummies (i.e., Middle Family and Large Family) and other control variables. We analyze single-manager funds in columns (1) and (4), team funds in columns (2) and (5), and all funds in columns (3) and (6). We add as an additional control variable the average performance of all funds in the family excluding the fund itself in columns (4) to (6). All other variables are defined in Table 1. Standard errors are computed using the time series of monthly estimates as in Fama-MacBeth (1973) and t-statistics are reported in parentheses. The superscripts ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Single	Team	All	Single	Team	All
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Middle Family	0.498**	0.464**	0.362**	0.370**	0.390*	0.303**
	(2.53)	(1.97)	(2.46)	(2.26)	(1.91)	(2.54)
Large Family	1.300***	0.778**	0.967***	0.964***	0.713**	0.777***
	(4.48)	(2.35)	(3.94)	(4.19)	(2.42)	(4.00)
Log Fund TNA	-0.238**	-0.372***	-0.286***	-0.252***	-0.367***	-0.292***
	(-2.46)	(-3.81)	(-3.48)	(-2.71)	(-3.78)	(-3.67)
Log Fund Age	0.026	0.228*	0.061	0.039	0.219*	0.062
	(0.21)	(1.84)	(0.63)	(0.34)	(1.84)	(0.66)
Expense Ratio	-0.689**	-0.743**	-0.778***	-0.544**	-0.575*	-0.623**
	(-2.39)	(-2.23)	(-2.79)	(-2.11)	(-1.89)	(-2.50)
Fund Flow	0.056**	0.103***	0.075***	0.049**	0.102***	0.072***
	(2.31)	(4.00)	(4.14)	(2.15)	(4.10)	(4.10)
Turnover Ratio	-0.094	-0.158	-0.027	-0.080	-0.079	-0.001
	(-0.40)	(-0.59)	(-0.12)	(-0.37)	(-0.32)	(-0.01)
Lagged Fund Return	0.011	0.019	0.014	0.009	0.017	0.013
	(0.90)	(1.49)	(1.20)	(0.75)	(1.39)	(1.09)
Team Fund			-0.303**			-0.258**
			(-2.27)			(-2.32)
Family Average Alpha				0.336***	0.315***	0.332***
				(38.61)	(36.70)	(55.90)
Constant	1.087	0.874	1.448*	1.334	0.923	1.631**
	(1.04)	(0.91)	(1.67)	(1.40)	(1.03)	(2.03)
Observations	163,391	205,965	369,356	163,391	205,965	369,356
R-squared	0.083	0.098	0.077	0.111	0.130	0.105
Number of Months	252	252	252	252	252	252
F-tests (p-value)						
Middle=Large	0.000	0.189	0.001	0.000	0.118	0.000

Table 8: **Fund Active Share, Return Gap, and Industry Concentration - Across Families**
This table reports Fama-MacBeth regression results of fund portfolio management activeness measures on two family size dummies (i.e., Middle Family and Large Family) and other control variables. We measure fund activeness using Active Share in columns (1) to (3), Return Gap in columns (4) to (6), and Industry Concentration in columns (7) to (9). We analyze single-manager funds in columns (1), (4), and (7), team funds in columns (2), (5), and (8), and all funds in columns (3), (6), and (9). We add as an additional control variable the average activeness of all funds in the family excluding the fund itself in all columns. All other variables are defined in Table 1. Standard errors are computed using the time series of monthly estimates as in Fama-MacBeth (1973) and t-statistics are reported in parentheses. The superscripts ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Active Share			Return Gap			Industry Concentration		
	Single	Team	All	Single	Team	All	Single	Team	All
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Middle Family	0.002***	0.009***	0.002***	0.250**	0.188	0.307***	0.017***	0.019***	0.018***
	(2.80)	(4.71)	(3.23)	(2.19)	(1.26)	(3.04)	(16.13)	(14.07)	(20.55)
Large Family	0.013***	0.001	0.007***	0.795***	0.003	0.896***	0.072***	0.026***	0.051***
	(12.93)	(0.77)	(6.35)	(5.15)	(0.01)	(3.65)	(44.08)	(14.45)	(27.84)
Log Fund TNA	-0.011***	-0.008***	-0.010***	-0.190***	-0.217***	-0.249***	-0.022***	-0.006***	-0.014***
	(-19.06)	(-11.97)	(-15.36)	(-3.65)	(-2.90)	(-4.19)	(-67.08)	(-15.75)	(-46.68)
Log Fund Age	0.002***	-0.004***	-0.001**	-0.180*	-0.026	-0.075	0.025***	0.002**	0.012***
	(4.41)	(-6.52)	(-2.01)	(-1.95)	(-0.18)	(-1.10)	(15.82)	(2.19)	(11.44)
Expense Ratio	0.080***	0.083***	0.084***	0.176	0.073	0.258	0.045***	0.042***	0.043***
	(48.25)	(28.28)	(39.66)	(0.91)	(0.28)	(1.15)	(27.63)	(40.02)	(46.95)
Fund Flow	0.001***	0.001***	0.000***	-0.036	-0.026	0.002	0.000	-0.000*	0.000
	(3.86)	(3.83)	(4.12)	(-1.14)	(-0.74)	(0.05)	(1.00)	(-1.95)	(0.80)
Turnover Ratio	0.013***	0.012***	0.010***	0.237**	-0.639	0.118	-0.002*	-0.007***	-0.001*
	(19.09)	(10.13)	(14.02)	(2.06)	(-0.70)	(0.76)	(-1.83)	(-6.02)	(-1.75)
Lagged Fund Return	0.000***	0.000***	0.000***	0.048***	0.088**	0.032***	0.000***	0.000*	0.000***
	(3.37)	(3.34)	(3.39)	(3.60)	(2.59)	(3.97)	(2.95)	(1.78)	(3.02)
Team Fund			-0.005***			0.074			-0.015***
			(-7.97)			(0.85)			(-21.34)
Family Average	0.336***	0.310***	0.331***	0.284***	0.223***	0.272***	0.588***	0.464***	0.565***
	(48.01)	(32.11)	(47.72)	(22.26)	(5.88)	(21.25)	(59.59)	(47.12)	(74.88)
Constant	0.467***	0.491***	0.476***	0.047	-0.943	0.360	-0.026***	0.012*	0.009
	(48.34)	(37.37)	(49.72)	(0.07)	(-0.72)	(0.71)	(-3.26)	(1.73)	(1.37)
Observations	153,604	192,236	345,840	141,674	173,771	315,445	143,221	171,757	314,978
R-squared	0.201	0.233	0.204	0.086	0.103	0.076	0.207	0.138	0.171
Number of Years	252	252	252	249	249	249	247	247	247
F-tests (p-value)									
Middle=Large	0.000	0.000	0.000	0.000	0.576	0.008	0.000	0.000	0.000

Table 9: **Fund Information Ratio - Across Families**

This table reports Fama-MacBeth regression results of fund information ratio on two family size dummies (i.e., Middle Family and Large Family) and other control variables. Each year we calculate the average of monthly four-factor alphas, volatility (i.e., standard deviation) of alpha, and information ratio (i.e., alpha mean over its standard deviation). We use average alpha as the dependent variable in columns (1) to (3), volatility of alpha in columns (4) to (6), and information ratio in columns (7) to (9). We analyze single-manager funds in columns (1), (4), and (7), team funds in columns (2), (5), and (8), and all funds in columns (3), (6), and (9). We add as an additional control variable the average dependent variable of all funds in the family excluding the fund itself in all specifications. All other variables are defined in Table 1. Standard errors are computed using the time series of yearly estimates as in Fama-MacBeth (1973) and t-statistics are reported in parentheses. The superscripts ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Four-Factor Alpha Mean			Four-Factor Alpha STD			Information Ratio		
	Single	Team	All	Single	Team	All	Single	Team	All
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Middle Family	0.561**	0.468	0.412**	0.090	0.196*	0.140*	0.062**	0.075	0.048**
	(2.74)	(1.43)	(2.78)	(0.94)	(1.79)	(1.88)	(2.51)	(1.60)	(2.60)
Large Family	1.131***	1.106*	0.913***	0.900***	0.247	0.565***	0.183***	0.151*	0.143***
	(4.45)	(2.00)	(3.28)	(7.45)	(1.62)	(4.61)	(5.33)	(2.06)	(4.14)
Log Fund TNA	-0.285***	-0.475***	-0.335***	-0.313***	-0.177**	-0.259***	-0.033**	-0.058***	-0.041***
	(-3.20)	(-3.52)	(-3.89)	(-5.79)	(-2.63)	(-4.83)	(-2.43)	(-3.62)	(-3.26)
Log Fund Age	0.074	0.317**	0.136	0.259***	0.033	0.130*	0.007	0.026	0.010
	(0.62)	(2.32)	(1.35)	(3.06)	(0.41)	(2.00)	(0.41)	(1.55)	(0.77)
Expense Ratio	-0.449	-0.643*	-0.574*	1.613***	1.717***	1.645***	-0.037	-0.030	-0.027
	(-1.40)	(-1.75)	(-1.89)	(11.07)	(12.48)	(13.01)	(-0.81)	(-0.67)	(-0.72)
Fund Flow	-0.006	-0.019	-0.012	0.006	0.003	0.009	-0.002	-0.004	-0.003
	(-0.25)	(-0.64)	(-0.60)	(0.40)	(0.22)	(0.78)	(-0.62)	(-1.09)	(-1.11)
Turnover Ratio	-0.025	0.174	0.056	0.472***	0.329***	0.431***	0.001	0.007	0.009
	(-0.12)	(0.57)	(0.25)	(5.71)	(3.80)	(5.77)	(0.05)	(0.18)	(0.38)
Lagged Fund Return	0.014	0.027	0.018	0.019	0.006	0.015	0.006*	0.008*	0.007*
	(0.42)	(0.85)	(0.58)	(0.80)	(0.25)	(0.63)	(1.88)	(2.07)	(2.00)
Team Fund			-0.232*			-0.359***			-0.042*
			(-1.74)			(-4.76)			(-2.02)
Family Average	0.386***	0.287***	0.351***	0.433***	0.344***	0.406***	0.361***	0.291***	0.343***
	(11.81)	(8.40)	(15.88)	(13.76)	(9.33)	(16.69)	(17.00)	(9.21)	(18.00)
Constant	-0.155	-0.245	0.130	0.918	1.802*	1.626*	-0.158	-0.163	-0.121
	(-0.13)	(-0.23)	(0.12)	(0.89)	(1.74)	(1.76)	(-1.09)	(-1.03)	(-0.93)
Observations	13,514	17,456	30,970	13,512	17,454	30,966	13,512	17,454	30,966
R-squared	0.107	0.113	0.096	0.247	0.261	0.246	0.094	0.092	0.082
Number of Years	21	21	21	21	21	21	21	21	21
F-tests (p-value)									
Middle=Large	0.009	0.043	0.013	0.000	0.644	0.000	0.000	0.061	0.001